Missouri Department of Natural Resources

Biological Stream Assessment Report

Dardenne Creek Study
Saint Charles County

March 2002 through September 2002

Prepared for:

Missouri Department of Natural Resources
Water Protection and Soil Conservation Division
Water Pollution Control Program

Prepared by:

Missouri Department of Natural Resources
Air and Land Protection Division
Environmental Services Program

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1.0 Introduction

At the request of the Water Pollution Control Program (**WPCP**), the Environmental Services Program's **(ESP)** Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Dardenne Creek in St. Charles County. This request was made due to concern by the WPCP that increased development in the Dardenne Creek watershed was causing poor water quality and habitat conditions in the creek and having an impact on the aquatic community. Data collected by Missouri Water Quality Monitoring Volunteers on Dardenne Creek from 1998-2001 suggested that the in-stream concentrations of dissolved oxygen, solids, turbidity, and pH were being affected by changes in the watershed (Missouri Department of Natural Resources, 2002a).

Water quality and macroinvertebrate samples were collected at North Fork Cuivre River, located in rural Pike County, and used as a control site to compare with Dardenne Creek. Land use within the North Fork Cuivre River watershed was largely agricultural and lacked the residential and commercial development present in the Dardenne Creek watershed (see Appendix B for a map of the sample collection locations on both streams). In addition, macroinvertebrate and water samples were collected during the fall 2002 sample season at South River, a biological criteria reference stream in Marion County. Samples collected here were then analyzed and compared to both Dardenne Creek and North Fork Cuivre River. Macroinvertebrate and water samples were collected in Dardenne Creek and North Fork Cuivre River in March of 2002 and at Dardenne Creek, North Fork Cuivre River, and South River in September of 2002 for analysis and evaluation of the biological integrity in the waterbodies. These samples were collected by Dave Michaelson, Cecilia Campbell, Steve Humphrey, and Ken Lister of the Environmental Services Program, Air and Land Protection Division.

Dave Michaelson and Cecilia Campbell performed an assessment of the in-stream habitat and riparian conditions in the spring of 2002 at Dardenne Creek and North Fork Cuivre River sample stations. Data was also collected to estimate the percent of benthic fine sediment found on the streambeds as a measure of the sediment load moving through each of the streams. This data was collected in July of 2002 by Dave Michaelson and Cecilia Campbell of the Environmental Services Program, Air and Land Protection Division. Water samples were collected from Dardenne Creek and North Fork Cuivre River in July, August, and September of 2002 and analyzed for the presence of fecal coliform bacteria. Kathy Rangen and Jason Holder of the Environmental Services Program, Air and Land Protection Division collected these samples.

A study plan was submitted to the WPCP on January 18, 2002 (see Appendix A). Ten null hypotheses were listed; five of the hypotheses were to test the macroinvertebrate assemblages, water chemistry, fecal coliform concentrations, benthic sediment percentages, and habitat quality, longitudinally, between Dardenne Creek sample stations. These hypotheses were to compare stations with best management practices in place versus stations without these practices. The other five hypotheses were to test the same parameters between Dardenne Creek, the regional control stream (North Fork Cuivre River), and the biocriteria reference stream (South River).

2.0 Study Areas

Dardenne Creek originates southwest of Foristell in eastern Warren County and flows through a rural landscape that becomes increasingly more developed as the creek flows downstream (see Appendix B). The sample stations are located in reaches of class “P” waters (those that permanently flow, even in periods of drought) and class “C” waters (those in which flow ceases in dry periods, but permanent pools remain to support aquatic life). The Missouri Water Quality Standards states the beneficial use designations for the study area of the creek are “warm water aquatic life protection, livestock and wildlife watering, and boating and canoeing.” Permanent flow of this stream begins in Section 22, Township 46 North, and Range 2 East (Missouri Department of Natural Resources, 2000a). Station 1 on Dardenne Creek is the only sample station classified with permanent flow. Stations 2 through 6 are classified as class "C" waters; during the fall 2002 sample season there was no surface flow at these stations, only isolated pools in the stream bed.

North Fork Cuivre River is formed in south central Pike County by the joining of Jasper Spring Branch and Irvine Branch southwest of Bowling Green, Missouri (Missouri Atlas and Gazetteer, 1998). Sample stations on North Fork Cuivre River are located in class "C" waters, but maintained flow even during the fall 2002 sample season. The designated beneficial uses for the study reaches are warm water aquatic life protection and livestock and wildlife watering (Missouri Department of Natural Resources, 2000a).

The South River originates northeast of Ely, Missouri, near the Marion and Ralls County line. The sample station on South River is located in a reach of class "C" waters, with the same beneficial uses designation as the North Fork Cuivre River sample stations. During the fall 2002 sample season there was flow within the sample reach.

Table 1 lists the land use percentages from the Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers EDU and around the sample stations on Dardenne Creek, North Fork Cuivre River, and South River. Land use data for the Cuivre and South River stations were derived from Thematic Mapper satellite data from 1991-1993 and interpreted by the Missouri Resource Assessment Partnership (MoRAP). The land use classifications assigned to these watersheds were measured on a 500-meter radius around each sample station. Data for land use in the Dardenne Creek watershed was collected for an Environmental Protection Agency study on urban land use changes and impacts (Environmental Protection Agency, 2003). Like the land use classifications on the North Fork Cuivre River and South River, the land use classifications on Dardenne Creek were also determined for a 500-meter radius around each sample station.

Table 1
Percent Land Use Within the Plains/Mississippi Tributaries between the
Des Moines and Missouri Rivers EDU and a Sampling Station 500-meter Radius

Location	Urban	Crop	Grass	Forest	Other
EDU	2.2	41.1	38.2	16.3	0.2
Dardenne Creek 1	0.4	0.3	17.2	66.2	15.9
Dardenne Creek 2	0.7	3.4	26.6	69.3	0.0
Dardenne Creek 3	1.2	1.9	45.3	51.6	0.0
Dardenne Creek 4	11.7	1.9	61.7	24.7	0.0
Dardenne Creek 5	2.7	0.0	56.6	39.6	1.1
Dardenne Creek 6	6.0	1.6	69.3	22.8	0.3
North Fork Cuivre River 1	0.0	39.2	30.9	29.9	0.0
North Fork Cuivre River 2	0.0	32.0	44.1	23.9	0.0
South River 1	0.0	30.5	52.2	17.3	0.0

3.0 Station Descriptions

Station Dardenne 1 [no legal description] was located on Dardenne Creek north of Lake 33 in Busch Conservation Area in St. Charles County. The samples were collected downstream of an old concrete bridge foundation. Geographic coordinates were measured at the upstream boundary of the sample reach (Lat. 38.738723, Long. -90.766514).

Station Dardenne 2 [(NE¼ sec. 21, T. 46 N., R. 2 E.)] was located downstream of the Route DD bridge in St. Charles County. Geographic coordinates were measured approximately 300 yards upstream from the property line into the Busch Conservation Area (Lat. 38.734096, Long. -90.796826).

Station Dardenne 3 [(Survey 418, T. 46 N., R. 2 E.)] was located downstream from the Hopewell Road Bridge in St. Charles County. Geographic coordinates were measured at the riffle downstream from the MDC fish sample station marker (Lat. 38.739552, Long. -90.817097).

Station Dardenne 4 [(Survey 891, T. 46 N., R. 2 E.)] was located upstream from the Hopewell Road Bridge in St. Charles County. Geographic coordinates were measured at the MDC fish sample station marker (Lat. 38.744768, Long. -90.834204).

Station Dardenne 5 [(NW¼ sec. 24 and NE¼ sec. 23, Survey 1807, T. 46 N., R. 1 E.)] was located downstream of the Route Z bridge in St. Charles County. Geographic coordinates were measured at the MDC fish sample station marker (Lat. 38.733956, Long. -90.871844).

Station Dardenne 6 [(E½ sec. 22, T. 46 N., R 1 E.)] was located upstream from the Route Z bridge in St. Charles County. Geographic coordinates were measured at the MDC fish sample station marker (Lat. 38.731129, Long. -90.887464).

Station North Fork Cuivre River 1 [(Section Line of 13/14, T. 51 N., R. 3 W.)] was located downstream from the County Road 325 bridge in Pike County. Geographic coordinates were measured just below the bridge (Lat. 39.193592, Long. -91.202815).

Station North Fork Cuivre River 2 [(E½ sec. 21, T. 46 N., R 2 E.)] was located upstream from the Highway 161 bridge in Pike County. Geographic coordinates were measured just upstream from the bridge (Lat. 39.234612, Long. -91.246665).

Station South River 1 [(NE¼ sec. 31, T. 58 N., R. 5 W.)] was located upstream of the County Road 403 bridge in Marion County. Geographic coordinates measured at this site in 1999 were Lat. 39.783394, Long. -91.500984.

4.0 Methods

4.1 Macroinvertebrate Collection and Analysis

A standardized sample collection procedure, the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure, was used to collect macroinvertebrate samples within each sample reach (Missouri Department of Natural Resources, 2001a). Dardenne Creek, North Fork Cuivre River, and South River were sampled as Riffle/Pool stream types, and once the samples were collected, the samples were then sorted, identified, and counted. As riffle/pool stream types, the macroinvertebrate samples were collected from flowing water over coarse substrate, non-flowing water over depositional substrate, and root-mat substrate along the banks. This information was then compared to biological criteria collected in the past from streams in the same EDU as the study streams.

Four metrics comprise the biological criteria used for comparison between streams: the total number of taxa found in the sample (hereafter referred to as TT), the total number of taxa found from the Ephemeroptera, Plecoptera, and Trichoptera insect orders (hereafter referred to as EPTT), the Biotic Index (hereafter referred to as BI), and the Shannon Diversity Index (hereafter referred to as SDI). The biological criteria calculated for the Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers EDU is listed in Table 2 for spring and in Table 3 for fall. These criteria were used as a comparison for data collected on Dardenne Creek, North Fork Cuivre River, and South River. Using values calculated from the TT, EPT, BI, and SDI data, a Stream Condition Index (hereafter referred to as SCI) score was assigned to the data for each sample station. The SCI scores were divided into three categories of impairment. Study stream reaches that scored from 16-20 were considered fully biologically sustaining, scores from

10-14 were considered partially biologically sustaining, and scores of 4-8 were considered non-biologically sustaining.

SCI scores were then compared longitudinally among the Dardenne Creek sites to determine differences between sample stations that could reflect a disturbance within the sample station reach. The Dardenne Creek SCI scores were also compared to the scores calculated from North Fork Cuivre River and South River data, the control and biocriteria reference streams of similar watershed size as Dardenne Creek and located within the same EDU.

Table 2
Riffle/Pool Biological Criteria for Spring/Warm Water Streams
in the Plains/Mississippi Tributaries between the
Des Moines and Missouri Rivers EDU

	Score = 5	Score = 3	Score =1
TT	>78	39-78	<39
EPTT	>17	8-17	<8
BI	<6.20	6.20-8.10	>8.10
SI	>3.19	1.60-3.19	<1.60

Table 3
Riffle/Pool Biological Criteria for Fall/Warm Water Streams
in the Plains/Mississippi Tributaries between the
Des Moines and Missouri Rivers EDU

	Score = 5	Score = 3	Score = 1
TT	>80	40-80	<40
EPTT	>18	9-18	<9
BI	<6.34	6.34-8.17	>8.17
SI	>3.11	1.56-3.11	<1.56

4.2 Physicochemical Data Collection and Analysis

Physical and chemical water quality measurements were taken at each sample station. Field measurements included temperature (ºC), pH, conductivity (µs/cm), and dissolved oxygen concentrations (mg/L) using the Field Measurement of Water Temperature (Missouri Department of Natural Resources, 1993), the Field Analysis for pH (Missouri Department of Natural Resources, 2001c), the Field Analysis for Specific Conductance (Missouri Department of Natural Resources, 2000b), and the Field Analysis for Dissolved Oxygen Using a Membrane Electrode Meter (Missouri Department of Natural Resources, 2002c). Grab samples were collected from each station and preserved in accordance with the Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations

(Missouri Department of Natural Resources, 2002b). For each grab sample, personnel from the Environmental Services Program's Chemical Analysis Section determined concentrations of nitrate/nitrite-N (hereafter known as NO_3-N), ammonia-N (hereafter known as NH_3-N), total phosphorus (hereafter known as TP), chloride (hereafter known as Cl), and total Kjeldahl nitrogen (hereafter known as TKN). Grab samples collected in the spring were also analyzed by the Chemical Analysis Section for non-filterable residue (hereafter known as NFR). Members of the Water Quality Monitoring Section analyzed each grab sample for turbidity (NTU).

Stream velocity measurements were collected at each sample station using a Marsh-McBirney Flow-Mate Model 2000. Discharge was then calculated using the methods set out in the Flow Measurement in Open Channels (Missouri Department of Natural Resources, 2001d).

Water samples were collected four times during the period of July 1, 2002 through September 4, 2002 near Dardenne Creek Stations 1, 3, and 5 to analyze for the presence of fecal coliform bacteria. This schedule allowed for efficient transfer of samples to the ESP laboratory and for data comparability between the collected samples. Sample collection (including duplicate sample collection) and analyses were conducted according to established MDNR protocols in the Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Considerations (Missouri Department of Natural Resources, 2002b), the Field Sheet and Chain of Custody Record (Missouri Department of Natural Resources, 2001b), and the Field Analysis of Fecal Coliform Bacteria (Missouri Department of Natural Resources, 2002d).

A visual method was used to estimate the percentage of in-stream deposits of benthic fine sediment. Within each sample reach, these deposits were visually estimated for percent sediment coverage per stream bottom area (fine sediment is less than ca. 2mm particle size). The estimates were made at three sample areas or grids: within the reach, at the upper margins of pools or the lower margins of riffle/run habitat, and where stream velocity decreased and fine sediment dropped out of the water column and collected on the streambed. Velocity was measured at each of the grids prior to taking the sediment readings. If the velocity was less than 0.5 feet per second (and the depth was less than 2.0 meters) the area was then used to obtain the sediment estimate reading.

The three grids within each sample reach consisted of six contiguous transects across the stream (see Figure 1). Each transect was determined by stretching a tape measure from bank to bank. One sample quadrat (ca. 0.25m x 0.25m) was placed directly on the substrate within each of the six transects using a random number that equated to one-foot increments (see Figure 2). The trailing edge of the quadrat was placed on the random foot increment. Two investigators visually estimated the percentage of the stream bottom covered by fine sediment within each quadrat. If the sediment estimates by the two investigators were within ten percent of each other, the estimate was accepted. If the estimates diverged more than ten percent, the investigators repeated the process until the estimates were within the acceptable margin of error. An average of the two estimates was then recorded and used for analysis.

The reach at Dardenne Creek 6 was comprised of isolated pools at the time the sediment estimation was made, so the benthic sediment estimate procedure was not conducted at that station. Conditions within the reach at Dardenne Creek 1 provided only one appropriate location for a grid to be set up to estimate benthic sediment. Conditions at Dardenne Creek 5 and North Fork Cuivre River 2 were such that only two grids were set up for the estimation of benthic sediment. Three grids were set up at all other sample stations and estimates completed.

In recognition of the fact that habitat availability and quality can directly affect the biological community, physical assessments of stream and riparian habitat were conducted at all stations on Dardenne Creek and North Fork Cuivre River in the spring of 2002. The assessments were used to score habitat at Dardenne Creek stations and compare it to scores collected at stations on North Fork Cuivre River, the control stream, using the procedure applicable to Riffle/Pool habitat in the MDNR Stream Habitat Assessment Project Procedure (Missouri Department of Natural Resources, 2000c). A measure for this study was for the total scores from the physical habitat assessment conducted at the Dardenne Creek sample stations to be at least 75% similar to the total scores of the assessments conducted at North Fork Cuivre River stations. If the habitat scores at Dardenne Creek and North Fork Cuivre River were 75% or greater in similarity, Dardenne Creek would be expected to support biological communities comparable to those at the North Fork Cuivre River stations.

The physicochemical data was compiled and presented in tabular form for comparison among sample stations on Dardenne Creek and between Dardenne Creek stations and those on the control and biocriteria reference streams (North Fork Cuivre River and South River).

The statistics program used for this project was Sigmastat, Version 2.03 (1997). A Kruskal-Wallis One Way Analysis of Variance and Dunn's Method of Multiple Comparison Procedures were used to determine possible differences between stations for fine sediment percent coverage. The ANOVA on Ranks was conducted for a more conservative identification of similarities or differences and Dunn's Method was used to compare the data (taking into account the unequal sample sizes).

Figure 1: Sediment Estimation Grids within a Macroinvertebrate Sample Station Reach

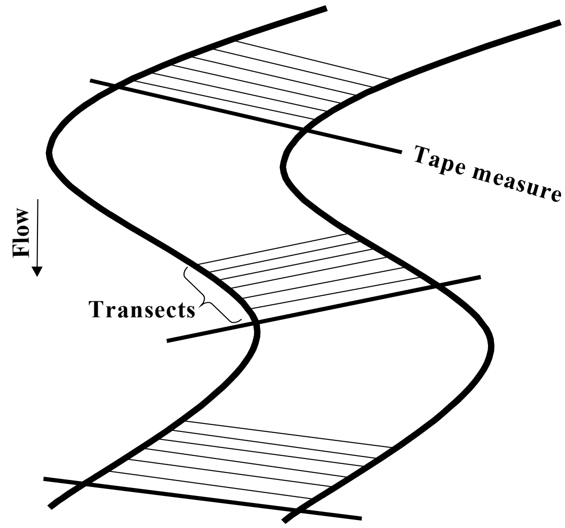
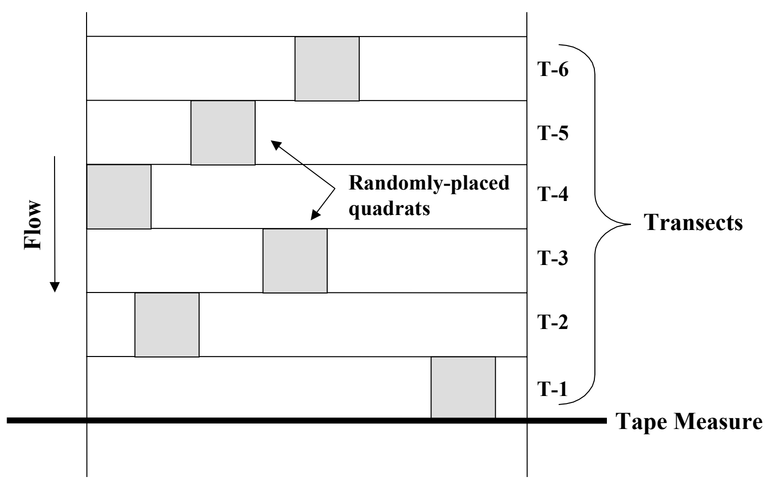


Figure 2: Sediment Sample Grid



4.3 Quality Assurance/Quality Control (QA/QC)

QA/QC procedures were used during the collection of macroinvertebrates during each season in this study, specifically through the collection of duplicate macroinvertebrate samples, following the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (Missouri Department of Natural Resources, 2001a). The samples were collected and identified and the data was run through a Quantitative Similarity Index for Taxa. This index accounted for the presence or absence of taxa and the relative abundance of each taxon within the duplicate samples at the sample station. Because the samples were collected at the same sample station, the communities would be expected to be identical and yield an index value of 100%. If the index values for a sample were found to be less than 65% similar, the inference would be that influences other than natural variation were affecting the community (e.g. sample collection procedures).

QA/QC procedures were also used in the surface water sample collection following the Quality Assurance/Quality Control for Environmental Data Collection (Missouri Department of Natural Resources, 2002e). Duplicate water samples were collected at some of the sample stations and the samples were analyzed and compared.

5.0 Observations

Stream stage appeared to be elevated at all sample stations during the spring 2002 sample collection period. This was in great contrast to the stream stage in the fall 2002 sample season. By the fall sample season, four of six sample stations on Dardenne Creek (Stations 3, 4, 5, and 6) had no flow, but consisted of some interconnected and isolated pools. Dardenne Creek 2 had continuous flow through the sample reach, however, it was so low it couldn't be measured with the flow meter. Continuous flow was found at Station 1 on Dardenne Creek and at both stations on North Fork Cuivre River, but the water level was extremely low.

A portion of this study was set up to compare differences found at sample stations that have best management practices in place to those stations that do not have best management practices in place in the watershed. During sample collection at Dardenne Creek, there were no best management practices in use along the sample reaches.

6.0 Data Results and Analyses

6.1 Biological Assessment

6.1.1 Dardenne Creek Longitudinal Comparison

Low flow conditions during the fall of 2002 at Dardenne Creek Stations 3, 4, 5, and 6 affected collection of the coarse substrate and root-mat habitats. This resulted in the collection of smaller samples of coarse substrate habitat at Station 3 and root-mat substrate at Stations 3 and 6; no coarse substrate samples were collected from Stations 4, 5, and 6 because riffles were dried up and only isolated patches of root-mat and non-flow habitat were present to sample.

Macroinvertebrate species composition at each of the sample stations on Dardenne Creek is listed by sample season in Tables 4 and 5. In the spring of 2002, the dominant family at each station was Chironomidae, comprising at least 74% of all Dardenne Creek samples (Table 4). The highest concentrations of Chironomidae were found at stations 3 and 4, where 94% and 91%, respectively, of the macroinvertebrates collected were from this family. The stations with the lowest percentage of Chironomidae were the stations located farthest downstream on Dardenne Creek, Stations 2 and 1 (macroinvertebrate samples were comprised of 74% and 75% Chironomidae, respectively). At these two stations, the most common families collected after Chironomidae were members of the Caenidae and Hyalellidae families; however, together they comprised less than 6% of the remaining samples. Clearly, members of the Chironomidae family dominated the macroinvertebrate samples from the Dardenne Creek stations in spring of 2002.

In contrast, fall samples collected on Dardenne Creek retained Chironomidae as the dominant family at many of the sample stations, but it comprised only half of the macroinvertebrate samples and at just two of the stations (Table 5). Stations 1, 3, 4a, and 4b (station 4 was a duplicate sample) had macroinvertebrate samples containing more than 40% chironomids, while Stations 2, 5, and 6 were comprised of less than 30% chironomids. Like the spring samples, Chrionomidae, Caenidae, and Hyalellidae were the most common families collected at Dardenne Creek (except at Station 1 where Hydropsychidae and Baetidae families were in greater numbers). Fall samples contrasted with the spring in that Caenidae outnumbered Chironomidae at Station 6 and Hyalellidae outnumbered Chironomidae at Station 5. In addition, all sample stations displayed a greater diversity of species in the fall sample than in the spring sample.

As expected, the opposite trend was found in the percentage of other macroinvertebrate orders and families, particularly those in the Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders collected at each sample station. These three orders were of particular interest because they are considered to be largely pollution sensitive taxa. In the spring, macroinvertebrates from these three orders comprised 2-13% of the sample, while in the fall they comprised 4-37% of the

Table 4. Macroinvertebrate Composition per Sample Station on Dardenne Creek, Spring 2002

	Dardenne Ck 6	Dardenne Ck 5	Dardenne Ck 4	Dardenne Ck 3	Dardenne Ck 2	Dardenne Ck 1
No. of Total Taxa	62	69	57	56	81	81
No. of EPT Taxa	16	12	11	12	16	16
% Ephemeroptera	2	2	1	<1	6	5
%Plecoptera	4	5	1	<1	6	2
%Trichoptera	<1	<1	0	<1	<1	<1
% Dominant Family						
Chironomidae	86	84	91	94	74	75
Perlodidae	2	3	----	----	2	----
Enchytraeidae	2	----	1	----	----	----
Perlidae	1	1	----	----	1	----
Empididae	1	----	----	----	----	----
Caenidae	----	1	----	----	5	3
Ceratopogonidae	----	1	1	----	1	1
Tubificidae	----	1	----	----	----	1
Tipulidae	----	1	1	----	----	----
Hyalellidae	----	----	----	----	3	3
Simulidae	----	----	----	----	1	2
Coenagrionidae	----	----	----	----	1	1
Nemouridae	----	----	----	----	1	----
Elmidae	----	----	----	----	----	1

Table 5. Macroinvertebrate Composition per Sample Station on Dardenne Creek, Fall 2002

	Dardenne Ck 6	Dardenne Ck 5	Dardenne Ck 4a	Dardenne Ck 4b	Dardenne Ck 3	Dardenne Ck 2	Dardenne Ck 1
No. of Total Taxa	58	62	49	53	90	82	96
No. of EPT Taxa	9	12	5	6	14	18	16
% Ephemeroptera	30	20	2	4	18	26	10
%Plecoptera	0	0	0	0	0	0	0
%Trichoptera	2	4	2	3	3	11	22
% Dominant Family							
Chironomidae	19	24	50	46	42	26	49
Caenidae	27	13	----	3	16	21	4
Ceratopogonidae	3	1	3	5	13	4	3
Tubificidae	2	3	10	3	1	1	1
Hyalellidae	11	35	13	12	4	8	2
Coenagrionidae	11	1	4	3	1	5	1
Elmidae	----	----	----	----	1	----	2
Physidae	5	----	----	----	2	3	----
Libellulidae	3	----	----	----	----	----	----
Planorbidae	2	1	2	4	----	----	----
Leptoceridae	2	4	1	2	----	----	----
Heptageniidae	1	2	----	----	----	1	1
Arachnoidea	1	----	----	2	----	4	2
Elmidae	1	2	2	4	----	2	----
Ephemeridae	----	3	----	----	----	----	----
Scirtidae	----	1	4	5	----	----	----
Planariidae	----	1	----	----	----	----	----
Ancylidae	----	----	----	2	----	----	----
Leptophlebiidae	----	----	1	1	----	----	----
Hydrophilidae	----	----	----	----	3	1	----
Hydroptilidae	----	----	----	----	1	----	2
Hydropsychidae	----	----	----	----	----	6	16
Philopotamidae	----	----	----	----	----	2	2
Baetidae	----	----	----	----	----	1	4

sample. At Dardenne Creek 3 and 4, the percentage of EPT taxa was the lowest of all stations, at 3% and 2%, respectively (while percent Chironomidae was 94% and 91%, respectively). In the fall, the percentage of EPT taxa reflected at least a two-fold increase at all stations. The increase was small at station 4, where the duplicate samples contained 4% and 7% EPT taxa. All other stations on Dardenne Creek produced greater than 20% EPT taxa in the samples. Regardless of sample season, the greatest percentage of EPT taxa were found at Dardenne Creek 2 and the lowest percentage of EPT taxa were collected at Station 4 (the spring sample collected at Dardenne Creek 3 also had a low percentage of EPT taxa).

Metric scores were calculated and summed to produce a total score, the stream condition index (SCI), for each sample station. The seasonal metric scores and SCI for Dardenne Creek study stations are listed in Tables 6 and 7. There were fewer habitats to sample in the fall, however, all stations on Dardenne Creek, except one (Station 5), had an increase in the SCI from the spring to fall sample season. At stations 1 and 2 (the only stations with all three habitats present during fall sample collection), the number of taxa increased and the diversity markedly increased from the spring to fall sample event. The Biotic and Shannon Diversity Index scores followed the same trend of improving from the spring to the fall sample season, and as a result, the SCI scores displayed that trend and improved from partially sustainable to fully sustainable.

Table 6
Dardenne Creek Metric Values and Scores, Spring 2002,
Using Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers
Biocriteria Reference Streams for Scores

Site No.	Total Taxa	EPT Taxa	Biotic Index	Shannon Index	Total Score	Sustainability
1 - Value	81	16	7.82	2.30		
1 - Score	5	3	3	3	14	Partial
2 - Value	81	16	7.97	2.21		
2 - Score	5	3	3	3	14	Partial
3 - Value	56	12	8.55	1.20		
3 - Score	3	3	1	1	8	Non-Sustainable
4 - Value	57	11	8.73	1.18		
4 - Score	3	3	1	1	8	Non-Sustainable
5 - Value	69	12	7.80	2.02		
5 - Score	3	3	3	3	12	Partial
6 - Value	62	12	8.34	1.45		
6 - Score	3	3	1	1	8	Non-Sustainable

In general, macroinvertebrate samples collected from Dardenne Creek Stations 1 and 2 consistently produced higher numbers of total and EPT taxa, the least tolerant organisms, and the most diverse taxa (see Figures 3-6). The stations located farther upstream (Stations 4, 5, and 6) usually displayed the lowest number of taxa, more pollution-tolerant species, and the least diverse assemblage of macroinvertebrates. The SCI scores at Stations 1, 2, and 3 reflected this trend (see Figure 7). Dardenne Creek Stations 1 and 2, the downstream stations, produced the highest SCI scores in both sample seasons, while Station 3 exhibited an elevated score in the fall sample season. The SCI score at Station 5 was 12 during both sample seasons, a partially biologically sustaining score. A list of all the taxa collected at each sample station is listed in Appendix C.

Table 7
Dardenne Creek Metric Values and Scores, Fall 2002,
Using Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers
Biocriteria Reference Streams for Scores

Site No.	Total Taxa	EPT Taxa	Biotic Index	Shannon Index	Total Score	Sustainability
1 - Value	96	16	6.45	3.39		
1 - Score	5	3	3	5	16	Full
2 - Value	82	18	6.96	3.31		
2 - Score	5	3	3	5	16	Full
3 - Value	90	14	7.26	3.27		
3 - Score	5	3	3	5	16	Full
4 - Value	49	5	7.74	2.95		
4 - Score	3	1	3	3	10	Partial
5 - Value	62	12	7.34	2.76		
5 - Score	3	3	3	3	12	Partial
6 - Value	58	9	7.71	2.95		
6 - Score	3	3	3	3	12	Partial

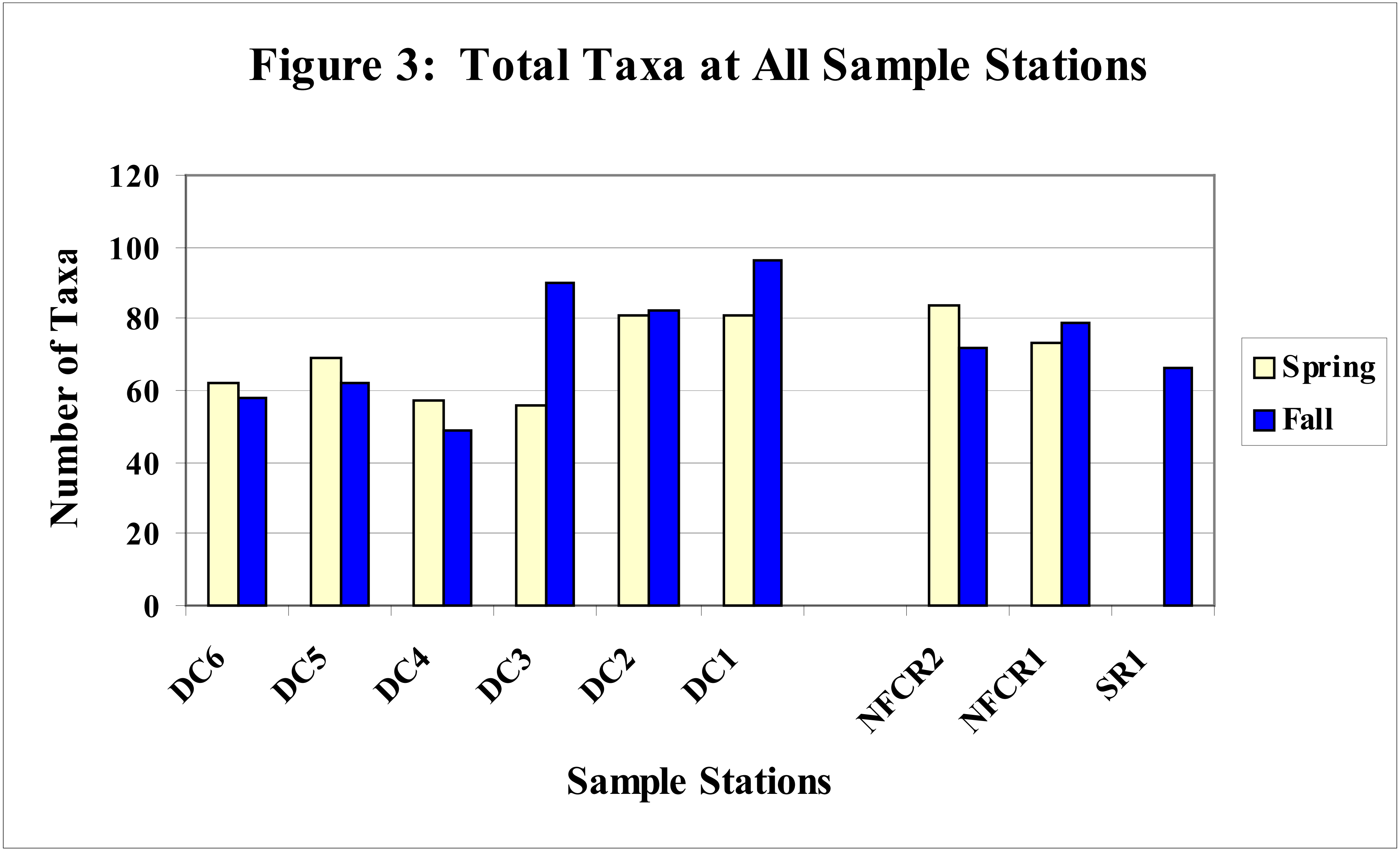


Figure 3: Total Taxa at All Sample Stations
Number of Taxa
120
100
80
60
40
20
0
DC6
DC5
DC4
DC3
DC2
DC1
NFCR2
NFCR1
SR1
Sample Stations
Spring
Fall

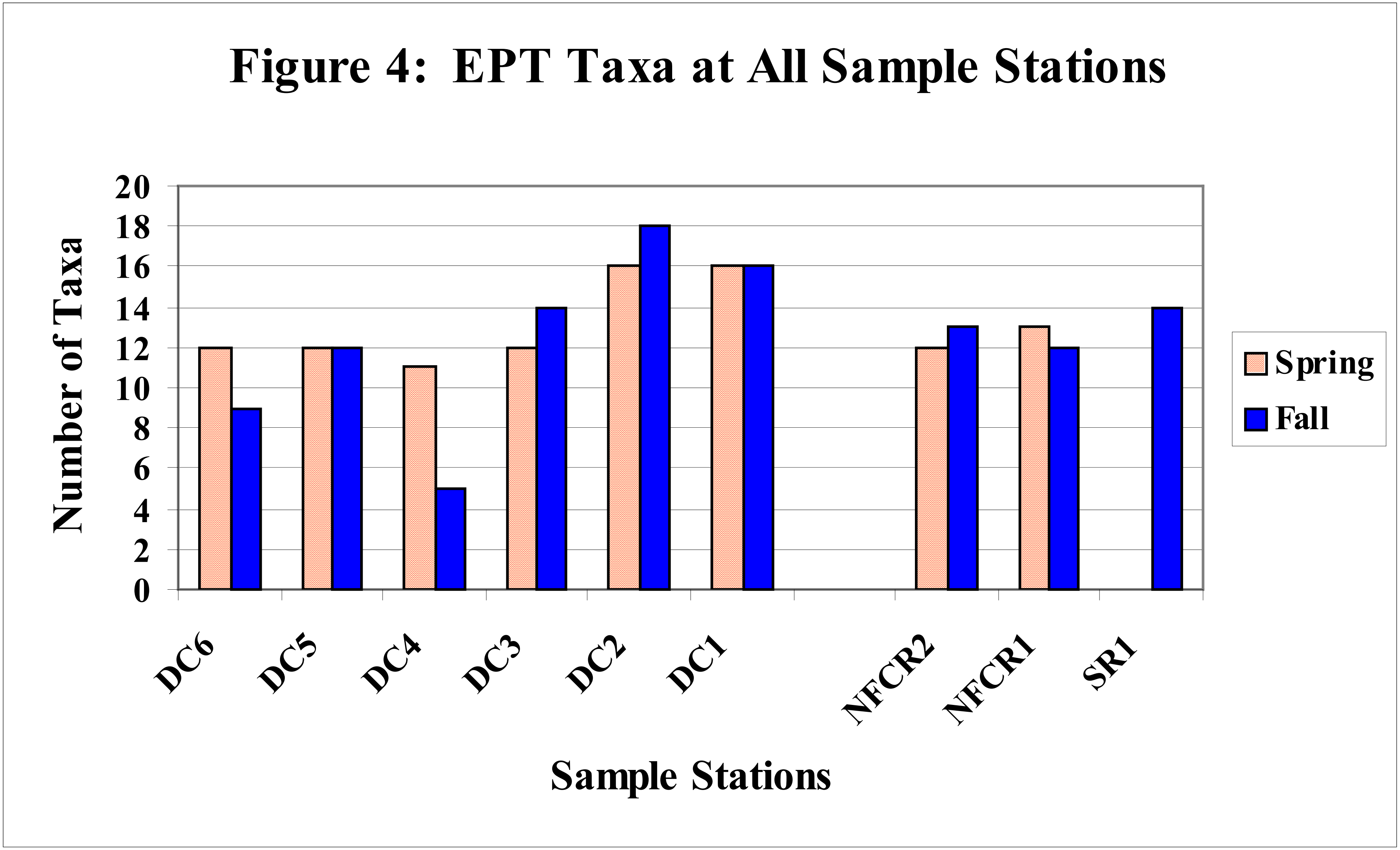


Figure 4: EPT Taxa at All Sample Stations
Number of Taxa
0
2
4
6
8
10
12
14
16
18
20
DC6
DC5
DC4
DC3
DC2
DC1
NFCR2
NFCR1
SR1
Sample Stations
Spring
Fall

Figure 5: Biotic Index Scores at All Sample Stations

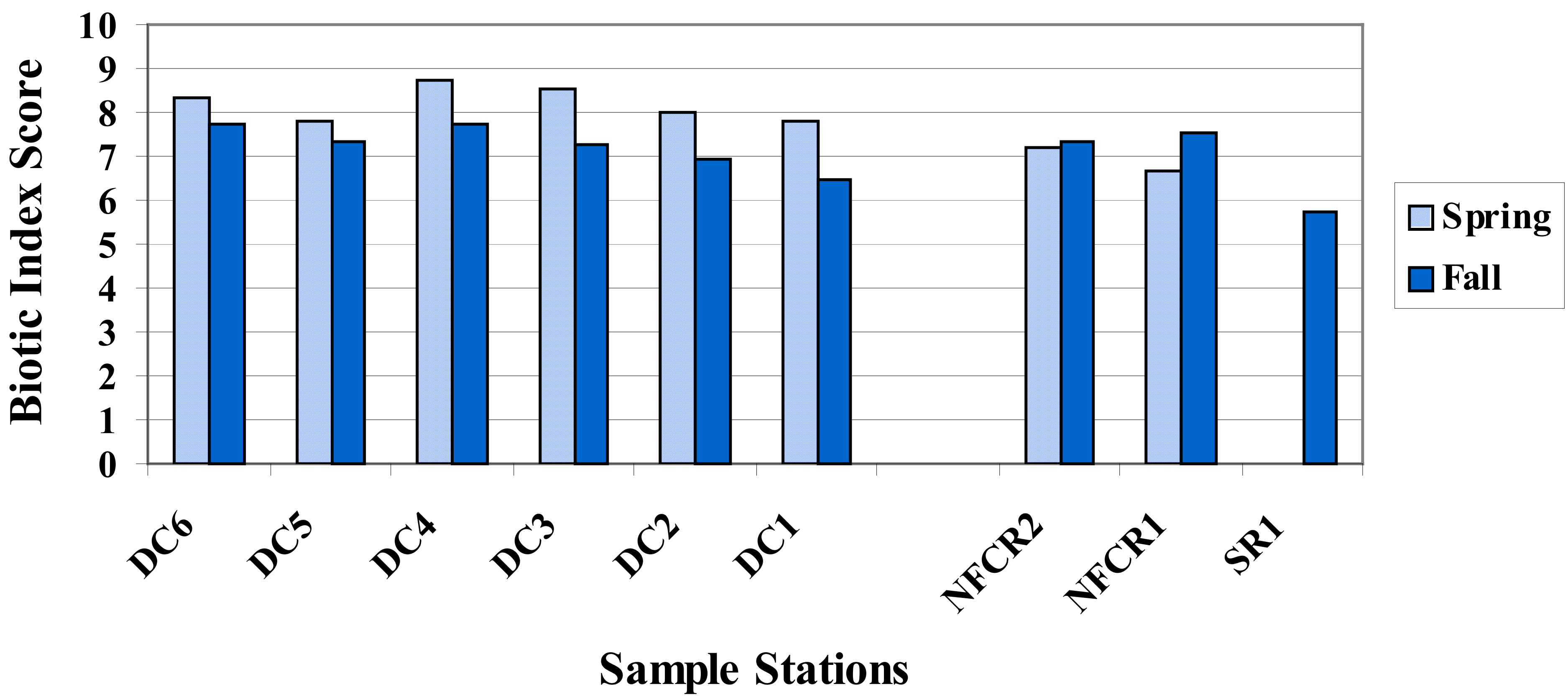


Figure 6: Shannon Diversity Index Scores at all Sample Stations

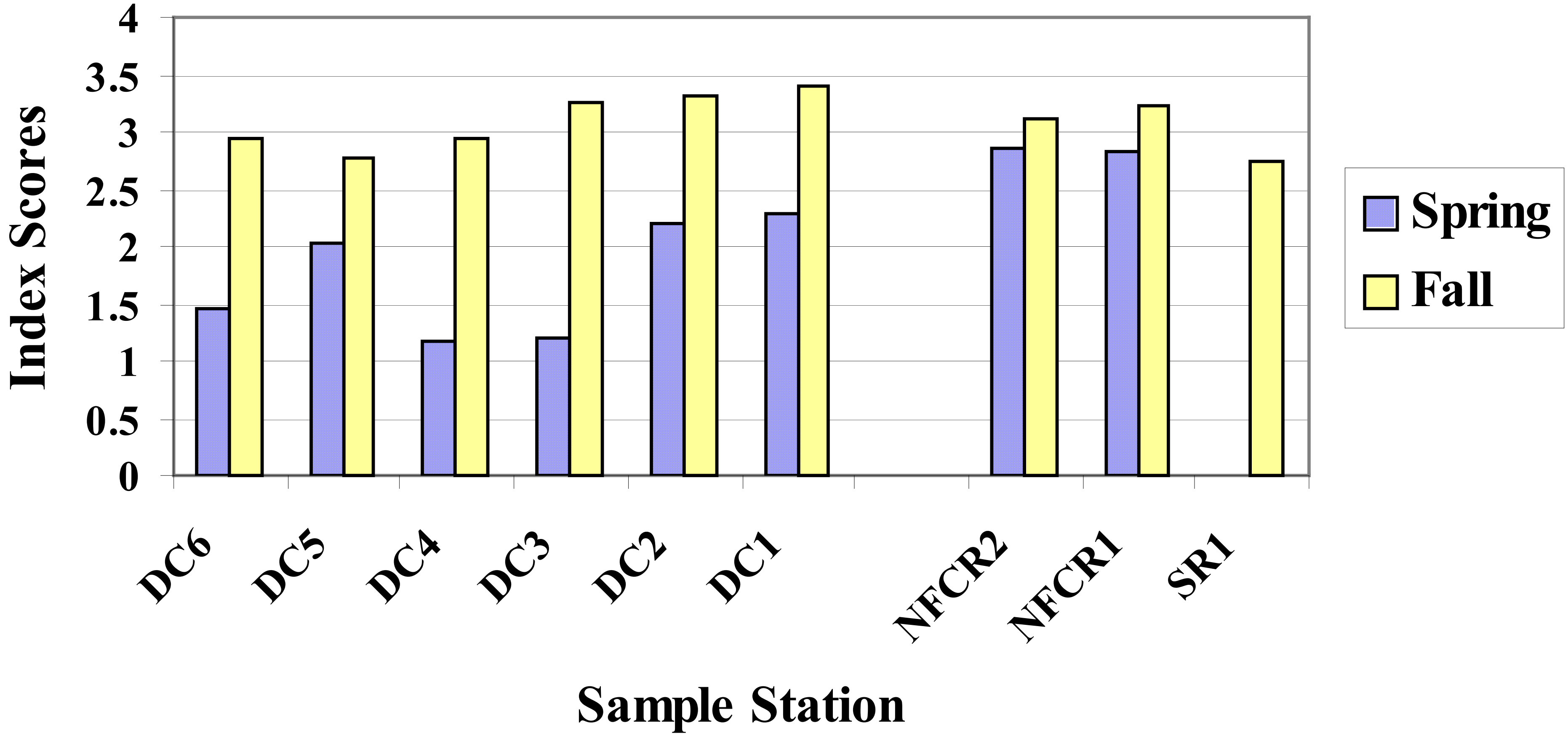
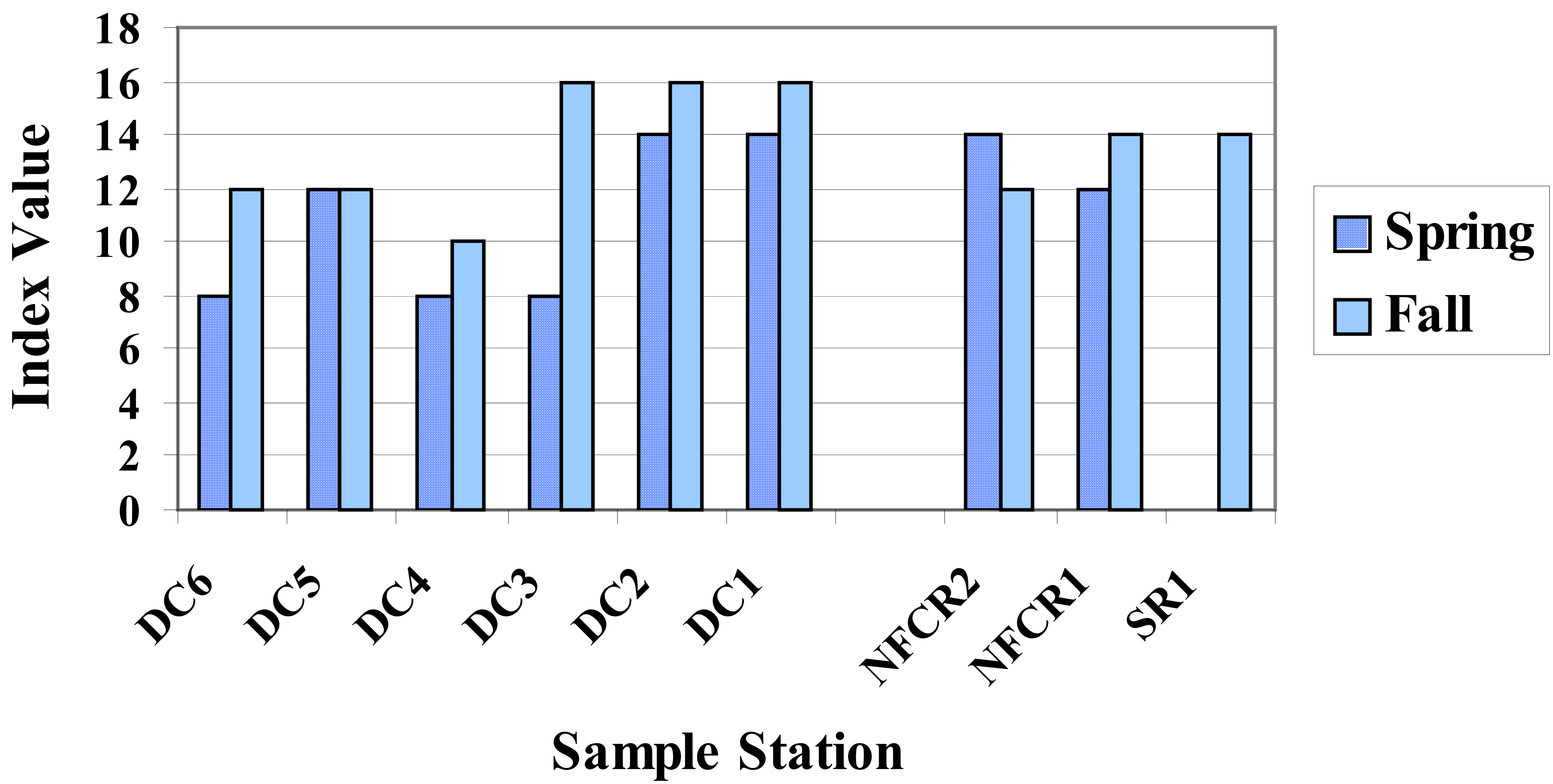


Figure 7: Stream Condition Index Values per Sample Station



6.1.2 North Fork Cuivre and South River Station Comparisons

Macroinvertebrate composition is listed for the two sample stations on North Fork Cuivre River and the South River in Table 8. In the spring, the dominant family at both stations on North Fork Cuivre River was Chironomidae, comprising at least 60% of the samples. Members of the family Caenidae also contributed 10-15% to the macroinvertebrate sample. Aquatic worms from the family Tubificidae, beetles from the Elmidae family, and Heptageniid mayflies contributed less than 15% of the remaining sample.

Although fall samples were more diverse than the spring samples, the dominant family was still Chrionomidae, making up more than 20% of the sample. Station 2 followed the trend of spring samples with mayflies of the Caenidae family following the Chironimidae, comprising 19% of the sample at that station. Members of two gastropod families, Ancylidae and Physidae, made up 23% of the sample at this station. All other families comprised less than 5% of the sample. Fall samples at Station 1 reflected a greater number of members of the family Elmidae than Station 2, with members of this family occurring most often after Chironomidae (approximately 15% of the sample). Members of the Tubificidae, Caenidae, Physidae, Planorbidae, and Tricorythidae families comprised 5-17% of the samples at Station 1 and all other families comprised less than 5% of the macroinvertebrate sample.

Different taxa and families were predominant in the fall sample collected at South River 1 than at the other sample stations (see Table 8). The dominant family collected here was the mayfly family Tricorythidae (36% of the sample). Although Chironomidae still comprised a significant portion of the sample (13%), the caddisfly family, Philopotamidae, contributed 10% of the sample. Of the remaining sample, no other families contributed greater than 6% of the sample.

Seasonal metric scores for North Fork Cuivre River and South River (fall 2002 only) are listed in Tables 9 and 10 and reflect some of the differences in the composition of the macroinvertebrate families. North Fork Cuivre River 1 displayed an increase in the total taxa and an improvement in diversity from the spring to fall sample season, resulting in a higher SCI score (from 12 to 14). Both of the spring and fall scores were partially sustainable. At Station 2 the number of total taxa decreased by 12, EPT taxa increased by 2, and the BI score improved from spring to fall. Even with the increase in EPT taxa and improvement in the BI, the SCI score dropped from 14 to 12, both of these still partially sustainable scores.

Table 8. Macroinvertebrate Composition per Sample Station on North Fork Cuivre River and South River, Spring and Fall 2002

	N Fk Cuivre River #2-Spring	N Fk Cuivre River 1a-Spring	N Fk Cuivre River 1b-Spring	N Fk Cuivre River 2-Fall	N Fk Cuivre River 1a-Fall	N Fk Cuivre River 1b-Fall	South River 1
No. of Total Taxa	84	73	72	72	79	76	66
No. of EPT Taxa	12	13	12	13	12	14	14
% Ephemeroptera	19	19	22	22	15	15	40
%Plecoptera	<1	<1	<1	0	0	0	0
%Trichoptera	<1	<1	<1	2	2	2	17
% Dominant Family							
Chironomidae	61	67	65	27	19	27	13
Enchytraeidae	----	1	1	----	----	----	----
Empididae	----	----	----	1	----	----	----
Caenidae	15	12	15	19	9	12	2
Ceratopogonidae	----	----	----	1	1	1	1
Tubificidae	9	2	2	3	17	9	6
Coenagrionidae	----	----	1	2	1	4	2
Elmidae	3	6	4	4	18	15	5
Heptageniidae	2	2	2	1	----	1	----
Baetidae	----	3	3	----	----	----	----
Physidae	----	----	----	6	7	5	1
Ancylidae	----	----	----	17	1	1	1
Arachnoidea	----	----	----	3	1	1	----
Hydrophilidae	----	----	----	3	3	2	1
Planorbidae	----	----	----	1	5	7	2
Tricorythidae	----	----	----	1	5	2	36
Hydropsychidae	----	----	----	----	2	1	1
Planariidae	----	----	----	----	2	3	1
Scirtidae	----	----	----	----	1	----	----
Sphaeriidae	----	----	----	----	1	----	----
Philopotamidae	----	----	----	----	----	----	10
Helicopsyche	----	----	----	----	----	----	3
Corixidae	----	----	----	----	----	----	2
Leptoceridae	----	----	----	----	----	----	2

Table 9
North Fork Cuivre River Metric Values and Scores, Spring 2002,
Using Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers
Biocriteria Reference Streams for Scores

Site No.	Total Taxa	EPT Taxa	Biotic Index	Shannon Index	Total Score	Sustainability
1 - Value	73	13	6.69	2.83		
1 - Score	3	3	3	3	12	Partial
2 - Value	84	12	7.17	2.87		
2 - Score	5	3	3	3	14	Partial

Table 10
North Fork Cuivre River (CR) and South River (SR) Metric Values and Scores, Fall 2002,
Using Plains/Mississippi Tributaries between the Des Moines and Missouri Rivers
Biocriteria Reference Streams for Scores

Site No.	Total Taxa	EPT Taxa	Biotic Index	Shannon Index	Total Score	Sustainability
CR 1 - Value	79	12	7.52	3.23		
CR 1 - Score	3	3	3	5	14	Partial
CR 2 - Value	72	13	7.33	3.11		
CR 2 - Score	3	3	3	3	12	Partial
SR 1 - Value	66	14	5.74	2.75		
SR 1 - Score	3	3	5	3	14	Partial

Total taxa increased by 9 going upstream from Station 1 to Station 2, while EPT taxa decreased by 1. The BI score dropped while the SDI showed a very slight improvement in diversity. These trends were reversed in the fall, with total taxa decreasing by 6 and EPT increasing by 1. The BI score improved slightly, and the SDI decreased a small amount. SCI scores at both stations over both sample seasons were either 12 or 14, partial sustainability.

A partially sustainable score was also calculated from the metrics for the South River sample collected in the fall of 2002. Total taxa at the station were 66 and 14 EPT taxa were collected. The BI score was 5.74 and the SDI score was 2.75.

6.1.3 Dardenne Creek versus Control and Reference Streams

Macroinvertebrate samples collected from the North Fork Cuivre River yielded data that was similar to that collected at Dardenne Creek (see Figures 3-6). The number of Total Taxa collected in the spring at North Fork Cuivre River 1 was less than those collected at Stations 1 and 2 on Dardenne Creek, but more than the four upstream stations on Dardenne Creek (see Figure 3). In the fall, the Total Taxa at the North Fork Cuivre River stations were less than those

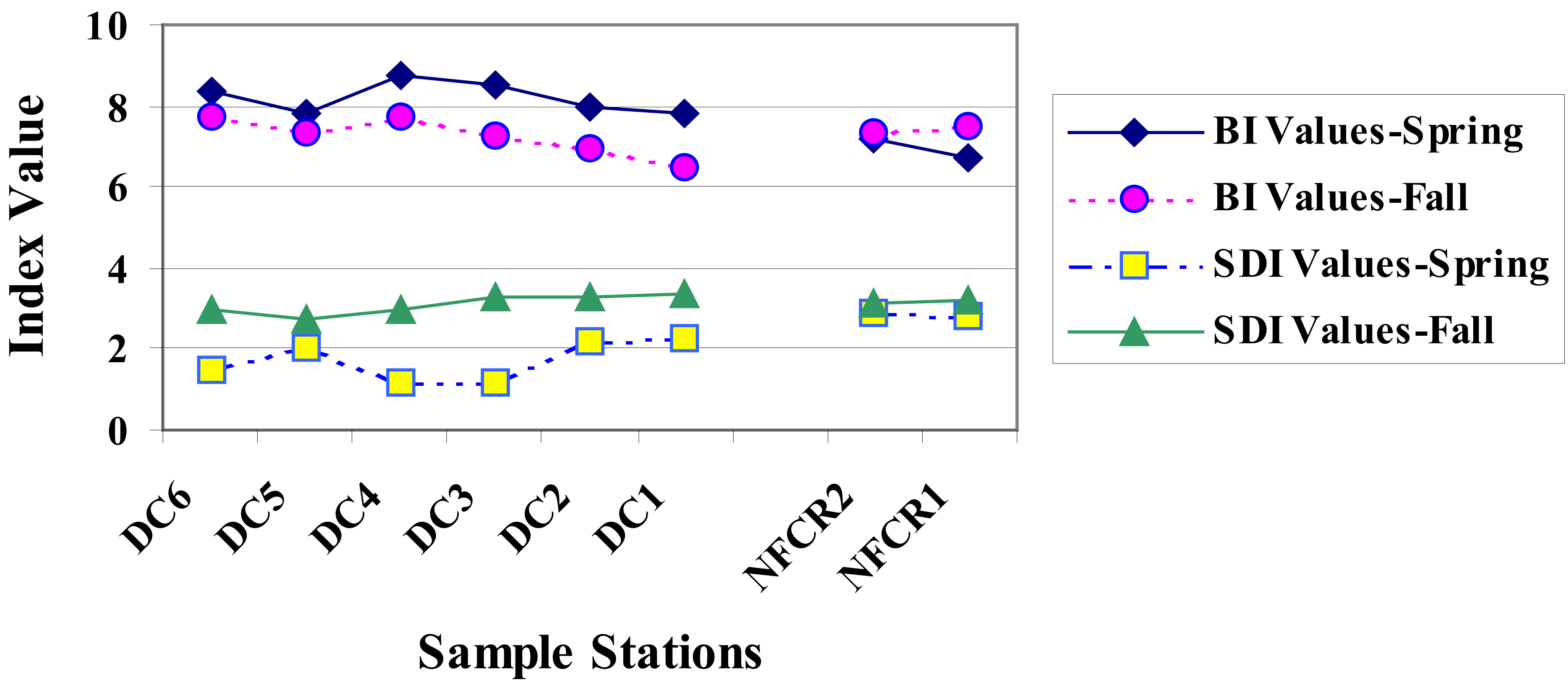
collected at Dardenne Creek Stations 1, 2, and 3. The number of EPT taxa collected during both seasons at North Fork Cuivre River Stations 1 and 2 were less than Dardenne Creek Stations 1 and 2, but equal to or higher than the upstream Dardenne stations (3 through 6).

Spring 2002 Biotic and Shannon Diversity Index scores at North Fork Cuivre River were better than those calculated for some of the Dardenne Creek stations (see Figure 8). Fall Biotic Index scores on the North Fork Cuivre River reflected a lower pollution tolerance than the three downstream stations on Dardenne Creek (Stations 1, 2, and 3), and a higher tolerance for pollution than the upstream stations. The Shannon Diversity Index scores at North Fork Cuivre River sample stations exhibited a lower diversity than the three downstream Dardenne Creek stations, but reflected a greater diversity than the Dardenne stations farthest upstream in the watershed. As expected, the SCI scores mimicked the trends of the individual metrics, with scores at the North Fork Cuivre River stations less than or equal to Dardenne Creek Stations 1, 2, and 5 during the spring season and greater than those for stations 3, 4, and 6 (see Figure 7). North Fork Cuivre River SCI scores in the fall season were lower than those from Dardenne Creek Stations 1, 2, and 3, equal to scores calculated for Dardenne Stations 5 and 6, and greater than the score from Dardenne Creek Station 4.

South River metric values were calculated for the fall only. The number of South River Total Taxa was lower than those collected at North Fork Cuivre River. South River Total Taxa were considerably lower than those at Dardenne Creek stations 1, 2, and 3 (16, 24, and 30 taxa, respectively) and considerably higher than those collected from the upstream stations 4, 5, and 6. The number of EPT taxa at South River was less than or equal to EPT taxa collected at Dardenne Creek Stations 1-3 and higher than those from the upstream Dardenne Creek stations and those at North Fork Cuivre River. Although the Biotic Index score at South River reflected the lowest pollution tolerance score (5.74) of all the stations sampled in the fall, the Shannon Diversity Index score from that station displayed the lowest diversity score of all the stations. In following the same trend of the individual metrics, the SCI score for South River fit in below SCI scores for Dardenne Creek Stations 1-3, but was equal to or greater than those for Dardenne Creek Stations 4-6 and the North Fork Cuivre River stations.

Species composition at sample stations on North Fork Cuivre River in spring 2002 was similar to that found on Dardenne Creek that same year. Greater than 60% of the macroinvertebrates collected on the North Fork Cuivre River were from the family Chironomidae. Station 1 had the highest percentage of Chironomidae. Like Dardenne Creek, the family most commonly found after Chironomidae was from Caenidae (comprised 12-15% of the samples). Fall samples at North Fork Cuivre River, like Dardenne Creek, were comprised of far less chironomids (less than 30% of the sample) and showed a greater diversity of species present in the samples. After chironomids, Caenidae and Elmidae were in the top four macroinvertebrate families present at each North Fork Cuivre River sample station.

Figure 8: Biotic and Shannon Diversity Index Values at Dardenne Creek and North Fork Cuivre River



Macroinvertebrate samples collected at South River in the fall of 2002 were comprised largely of the mayfly family Tricorythidae (36%). Chironomidae comprised only 13% of the sample, followed by the caddisfly family Philopotamidae (10%). Although members of the Tricorythidae family were collected in the fall at stations on North Fork Cuivre River and Dardenne Creek, this family comprised a far smaller percentage of the macroinvertebrate assemblage, especially at Dardenne Creek where Tricorythidae made up less than 1% of the sample. Members of the caddisfly family, Philopotamidae, were collected at Dardenne Creek and North Fork Cuivre River but in far fewer numbers than at South River. The majority of them were collected in the fall at stations 1 and 2 on Dardenne Creek.

6.2 Physicochemical Data

Stream width and discharge measurements at the sample stations on Dardenne Creek, North Fork Cuivre River, and South River are listed in Table 11. Dardenne Creek widened a bit in the midreaches. In general, discharge increased as it was measured at each downstream station (see Figure 9). In the spring of 2002 discharge increased with each downstream station, with the exception of station 2, which displayed discharge lower than both Stations 1 and 3. These two stations (1 and 3) were sampled within 24 hours of two rainfall events that contributed one and one-half inches to the watershed. Station 2 was sampled two days after Stations 1 and 3. No other rainfall events had occurred in those two days, so the discharge at Station 2 was considerably lower than at Stations 1 and 3. In the fall of 2002, flow was extremely low in the downstream reaches and was non-existent in the upper reaches of Dardenne Creek, where water was in isolated pools.

At the sample stations on North Fork Cuivre River, station 2 was narrower in width and reflected a lower discharge than Station 1 in both the spring and fall 2002 seasons. In the spring, discharge measured at Stations 1 and 2 of the North Fork Cuivre River was comparable to that measured in the upper reaches of Dardenne Creek (stations 5 and 6). In the fall, however, discharge at both North Fork Cuivre River sample stations and on South River was greater than that measured at any of the stations on Dardenne Creek.

Figure 9: Discharge on Dardenne Creek and North Fork Cuivre River, 2002

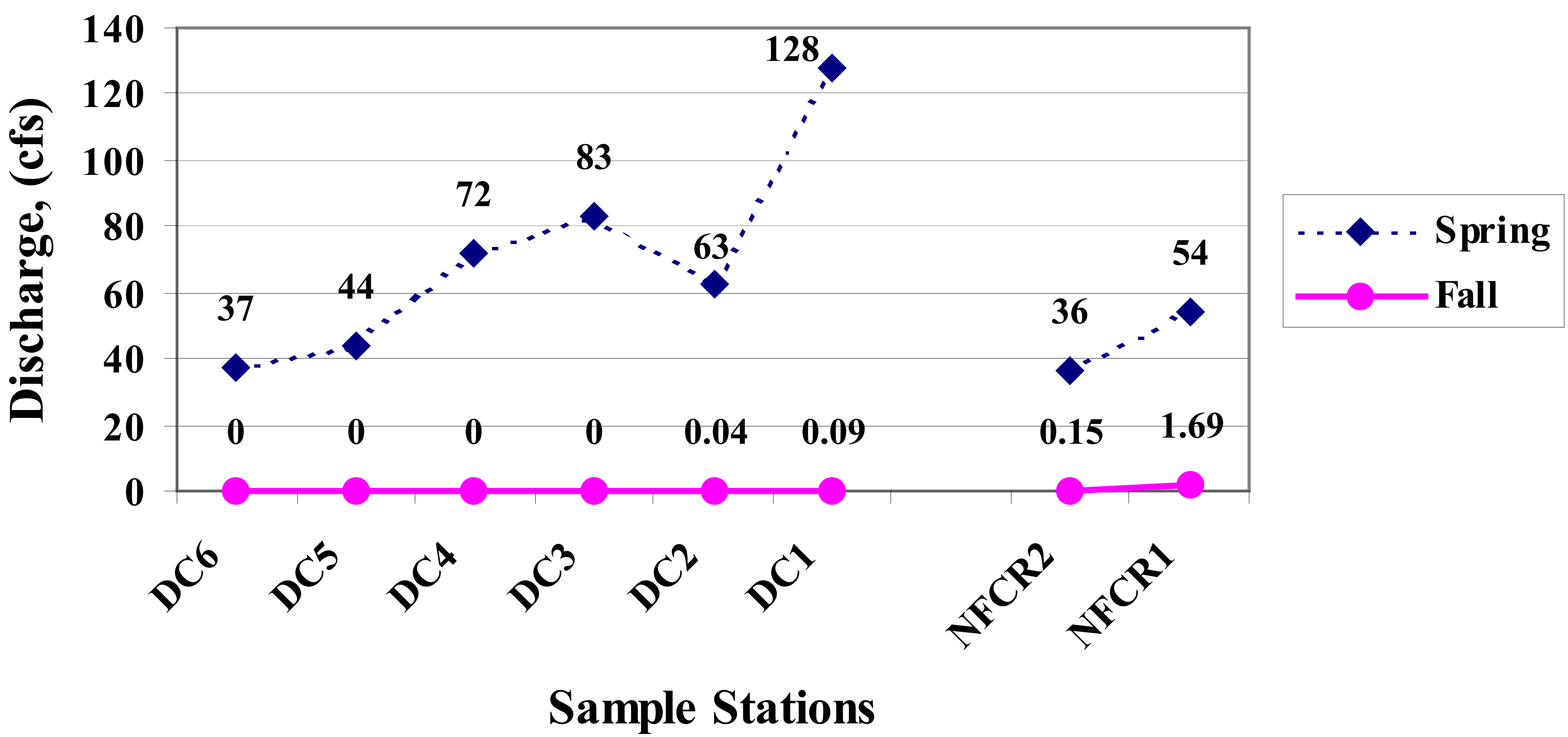


Table 11
Stream Width and Flow at all Stations

Station Name	No.	Avg. Width (ft)	Spring 2002 Discharge (cfs)	Fall 2002 Discharge (cfs)
Dardenne Creek	1	60	127	0.09
Dardenne Creek	2	66	63.1	<0.05
Dardenne Creek	3	72	83	0.00
Dardenne Creek	4	57	72	0.00
Dardenne Creek	5	60	44	0.00
Dardenne Creek	6	51	36.9	0.00
North Fork Cuivre River	1	75	54	1.69
North Fork Cuivre River	2	69	36	0.15
South River	1	--	--	0.50

Water quality parameters measured at all stations during both sample seasons are listed in Tables 12 and 13. In the spring, samples collected at the stations on Dardenne Creek displayed few general trends. Conductivity generally increased with downstream samples, but the increase was small. In the fall, this trend was reversed, with higher conductivity measurements recorded upstream and generally decreasing downstream. Conductivity readings were higher in the fall than in the spring, with measurements from the isolated pools at stations 5 and 6 two times the conductivity measured in the spring. Fall temperature readings were generally higher at stations 5 and 6 than at the downstream stations. The two sample stations on North Fork Cuivre River exhibited little difference in pH, conductivity, temperature, and dissolved oxygen readings in either season.

Table 12
In Situ Water Quality Measurements at all Stations - Spring 2002

Station	Parameter			
	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Dissolved O_2 (mg/L)
Dardenne Creek 1	8	247	6	13.1
Dardenne Creek 2	7.9	267	8	11.1
Dardenne Creek 3	7.4	225	6	13
Dardenne Creek 4	7.9	222	10	11.5
Dardenne Creek 5	7.8	210	6	10.4
Dardenne Creek 6	8.2	210	10	12.2
North Fork Cuivre River 1	7.9	383	4	12.7
North Fork Cuivre River 2	8.1	372	4	13.9

Small differences were found in water quality measured in Dardenne Creek compared to the North Fork Cuivre River sample stations. The pH readings ranged from 7 to 8 in both seasons between all sample stations, so there was no apparent trend in this parameter between the stations or sample season. Conductivity measurements were also lower at most Dardenne Creek and South River stations during both sample periods (with the exception of Dardenne Creek 6 where the highest conductivity measurement was taken in the fall). In each season, temperature measurements between stations were within four degrees of each other. As expected, dissolved oxygen readings were higher in the spring at all stations, with the stations on the North Fork Cuivre River producing generally higher concentrations than those at either South River or Dardenne Creek.

Table 13
In Situ Water Quality Measurements at all Stations - Fall 2002

Station	Parameter			
	pH	Conductivity (umhos/cm)	Temperature (degrees C)	Dissolved O_2 (mg/L)
Dardenne Creek 1	7.8	374	21	6.21
Dardenne Creek 2	7.3	411	20.5	6.1
Dardenne Creek 3	7.8	420	19.5	8.17
Dardenne Creek 4	7.4	406	19.5	5.78
Dardenne Creek 5	---	494	20.5	5.34
Dardenne Creek 6	7.8	598	23	7.43
North Fork Cuivre River 1	7.7	534	22	8.35
North Fork Cuivre River 2	7.8	543	22	8.58
South River 1	8	470	21.5	8

Results of the analyses of nutrients, suspended solids, and turbidity in water samples collected in the fall and spring are listed below in Tables 14 and 15. Turbidity was higher at all stations in the spring. Although turbidity generally increased as samples were collected downstream, turbidity at Station 2 was considerably lower than turbidity measured at Stations 3 and 1. The highest turbidity measurements were found at Station 1 and the lowest turbidity reading was taken at Station 6. All spring NH_3-N samples on Dardenne Creek were below 0.05 mg/L. Concentrations of NO_3-N increased steadily, but slightly, as samples were collected downstream, a trend that was mimicked by the TKN concentrations (with the exception of Station 2). Concentrations of Cl, TP, and NFR also increased, generally, from upstream stations to downstream stations, again with the exception of Station 2. Concentrations of TKN, TP, and NFR at Station 2 were comparable or lower than concentrations of these parameters collected at Station 6, the station farthest upstream. The Cl concentration at Station 2 was comparable to concentrations measured above Station 3.

Fall readings among Dardenne Creek stations revealed several similar trends to the spring readings. Again, NH_3-N concentrations were consistently low and TKN concentrations generally increased downstream. Concentrations of NO_3-N were consistently low at all stations and TP concentrations in Dardenne Creek were similar (slightly elevated at Station 2). Chloride concentrations varied a great deal, with the lowest concentration collected at Station 4 and the highest concentration found at Station 6. Chloride concentrations at the other stations were in between Stations 2 and 6 concentrations and were similar. Turbidity measurements on Dardenne Creek were lower in the fall than in the spring and did not reveal any trends in the concentrations. The highest turbidity was measured at Station 3 and elevated readings were found at Stations 4 and 6.

Table 14
Water Quality Parameters at all Stations - Spring 2002

Site/Station	Parameter						
	Turbidity (NTU)	NH_3-N (mg/L)	NO_3+NO_2-N (mg/L)	TKN (mg/L)	Cl (mg/L)	TP (mg/L)	NFR (mg/L)
Dardenne Creek 1	39.4	<0.05*	0.47	0.79	16.6	0.12	25
Dardenne Creek 2	21.9	<0.05*	0.43	0.35	15.7	0.06	<5*
Dardenne Creek 3	36.3	<0.05*	0.41	0.58	16.8	0.11	17
Dardenne Creek 4	27	<0.05*	0.39	0.61	14.9	0.09	6
Dardenne Creek 5	28.3	<0.05*	0.36	0.54	14.2	0.09	6
Dardenne Creek 6	24.9	<0.05*	0.32	0.51	14.5	0.07	5
North Fork Cuivre River 1	28.2	<0.05*	1.73	0.51	27.0	0.11	18
North Fork Cuivre River 2	32.3	<0.05*	1.63	0.74	29.4	0.12	20

Table 15
Water Quality Parameters at all Stations - Fall 2002

Site/Station	Parameter					
	Turbidity (NTU)	NH_3-N (mg/L)	NO_3+NO_2-N (mg/L)	TKN (mg/L)	Cl (mg/L)	TP (mg/L)
Dardenne Creek 1	5.53	<0.05*	<0.05*	0.37	12.0	0.07
Dardenne Creek 2	5.1	<0.05*	<0.05*	0.38	14.5	0.11
Dardenne Creek 3	11	<0.05*	0.07	0.28	12.3	<0.05*
Dardenne Creek 4	7.54	<0.05*	0.06	0.32	9.24	0.06
Dardenne Creek 5	4.01	<0.05*	<0.05*	0.21	16.2	<0.05*
Dardenne Creek 6	8.49	<0.05*	<0.05*	0.27	52.8	<0.05*
North Fork Cuivre River 1a	18.4	<0.05*	0.12	0.50	14.6	0.13
North Fork Cuivre River 2	9.93	<0.05*	0.75	0.30	24.6	0.06
South River 1	4.92	<0.05*	0.39	<0.2*	29.3	0.07

Spring samples collected on the North Fork Cuivre River exhibited similar concentrations of turbidity, NH_3-N, Cl, TP, and NFR (see Table 14). Spring turbidity measurements were elevated at both sample stations. Concentrations of NH_3-N in spring were below the limit of detection at both stations, while the other parameters appeared to be elevated. Although both North Fork Cuivre River sample stations had high concentrations of NO_3-N, Station 1 had a bit higher concentration than Station 2. Spring concentrations of TKN were also elevated at both stations, however, the concentrations were higher at Station 2 than Station 1.

Fall samples at North Fork Cuivre River varied considerably and only NH_3-N and TP exhibited low concentrations with low variances. Turbidity measurements were lower at both North Fork Cuivre River stations in the fall than in the spring, however, the turbidity at Station 1 was approximately two times that measured at Station 2. Concentrations of NO_3-N were significantly higher at Station 2 than Station 1a, and Cl concentrations were also considerably higher at Station 2 than Station 1. This trend was reversed with the concentrations of TKN and TP, with both nutrients displaying higher concentrations at the downstream station, Station 1a.

Water quality and nutrient measurements varied a great deal between stations on Dardenne Creek, North Fork Cuivre River, and South River. An exception to this statement was the concentration of NH_3-N, which was below the limit of detection (0.05 mg/L) at all sites during both spring and fall sample seasons. Spring NO_3-N concentrations at Dardenne Creek were one-third or less than those measured at North Fork Cuivre River stations. Concentrations of TKN were comparable at all stations during the spring, while TP concentrations were the same or slightly higher at the North Fork Cuivre River sample stations. North Fork Cuivre River stations exhibited spring Cl concentrations that were around two times the concentrations in samples collected on Dardenne Creek. Spring NFR concentrations at North Fork Cuivre River were comparable with two downstream stations on Dardenne Creek (Stations 1 and 3), with these concentrations at least three times the concentrations in samples collected at the other four stations on Dardenne Creek. Elevated turbidity readings were measured in the spring, when North Fork Cuivre River readings were comparable to those measured at stations in the lower reaches of Dardenne Creek (those below Station 5 on Dardenne Creek). Turbidity readings at Stations 3 and 1 on Dardenne Creek were the highest measured in the spring.

In the fall, concentrations of NO_3-N were much lower than concentrations measured in the spring at all sample stations. Concentrations at Dardenne Creek stations were at or below the limit of detection, while concentrations at South River and North Fork Cuivre River stations were at least two times the amounts measured at the Dardenne Creek stations. The highest concentration of NO_3-N was measured at North Fork Cuivre River Station 2. TKN concentrations were below the limit of detection at South River, while concentrations at Dardenne Creek stations were comparable to the TKN concentration measured at North Fork Cuivre River Station 2. Station 1 on North Fork Cuivre River displayed the highest fall concentration of TKN (0.50 mg/L). Fall Cl concentrations were lowest on all but one of the stations on Dardenne Creek and comparable with the concentration measured at Station 1a of the North Fork Cuivre River. North Fork Cuivre River Station 2 and South River had similar concentrations of Cl (almost two times the

amounts measured at five Dardenne Creek stations). The highest fall concentration of Cl was found at Station 6 of Dardenne Creek (52.8 mg/L). TP concentrations in the fall were at or below the limit of detection at five of the six sample stations on Dardenne Creek. These concentrations were comparable with the concentrations measured at North Fork Cuivre River 2 and also on South River. Dardenne Creek 2 had the highest concentration found on that creek (0.11 mg/L), a concentration that was comparable to the concentration found at North Fork Cuivre River 1a (0.13 mg/L). Fall turbidity measurements were lower than those measured at all stations in the spring, with the lowest reading at the sample station on South River and some comparable low readings measured at Stations 1, 2, and 5 on Dardenne Creek. Readings at Dardenne Creek Stations 3, 4, and 6 and North Fork Cuivre River Station 2 were a bit higher and the highest fall turbidity reading was measured at North Fork Cuivre River Station 1 (18.4 NTU).

6.3 Fecal Coliform Samples

Samples were collected throughout the summer at or near Dardenne Creek Stations 1, 3, and 5 and North Fork Cuivre River Stations 1 and 2 for the presence of fecal coliform bacteria (see Table 16). Samples collected in July indicated that Dardenne Creek Station 5 had the highest count of fecal coliform bacteria of both Dardenne Creek and North Fork Cuivre River samples. North Fork Cuivre River 1 and 2 produced higher counts of bacteria than either Dardenne Creek 3 or 1 for the two July samples. In the set of August samples, Dardenne Creek Station 1 had the highest number of bacteria on the creek (279 colony-forming units) and exceeded the amount found at North Fork Cuivre River 2 (120 colony-forming units). The highest count found at all stations in August was at North Fork Cuivre River 1, with a count of 570 or 900 colony-forming units (a duplicate sample was collected and analyzed from this station).

Table 16
Dardenne Creek and North Fork Cuivre River Fecal Coliform Results

Station No.	Station Name and Description	Sample No.	Collection Date	Discharge (cfs)	Fecal Coliform (cfu/100 ml)
5	Dardenne Creek-Highway Z	0216741	7-2-02	0.27[1]	262
5	Dardenne Creek-Highway Z	0223550	7-23-02	No flow	685
5	Dardenne Creek-Highway Z	0226267	8-13-02	No flow[1]	40
5	Dardenne Creek-Highway Z	0226293	9-4-02	No flow[1]	35
3	Dardenne Creek-Hopewell Rd	0216742	7-2-02	No flow[1]	95
3	Dardenne Creek-Hopewell Rd	0216743[2]	7-2-02[2]	No flow[1]	70
3	Dardenne Creek-Hopewell Rd	0223551	7-23-02	0.11[1]	228
3	Dardenne Creek-Hopewell Rd	0226268	8-13-02	No flow[1]	65
3	Dardenne Creek-Hopewell Rd	0226294	9-4-02	No flow[1]	125
1	Dardenne Creek-Busch CA	0216744	7-2-02	3.65[1]	70
1	Dardenne Creek-Busch CA	0223552	7-23-02	1.12[1]	238
1	Dardenne Creek-Busch CA	0223553[2]	7-23-02[2]	1.12[1]	253
1	Dardenne Creek-Busch CA	0226269	8-13-02	5.43	279
1	Dardenne Creek-Busch CA	0226295	9-4-02	No flow[1]	135
2	N Fk Cuivre River-Highway 161	0216745	7-2-02	3.11	210
2	N Fk Cuivre River-Highway 161	0210937	7-23-02	3.94	440
2	N Fk Cuivre River-Highway 161	0226261	8-13-02	2.71	120
2	N Fk Cuivre River-Highway 161	0226296	9-4-02	1.86	100
1	N Fk Cuivre River-County Road 325	0216746	7-2-02	0.97	125
1	N Fk Cuivre River-County Road 325	0210938	7-23-02	4.04	440
1	N Fk Cuivre River-County Road 325	0226262	8-13-02	1.82	900
1	N Fk Cuivre River-County Road 325	0226263[2]	8-13-02[2]	1.82	570
1	N Fk Cuivre River-County Road 325	0226297	9-4-02	0.23	520
1	N Fk Cuivre River-County Road 325	0226298[2]	9-4-02[2]	0.23	370

Notes: 1. Discharge was measured the day prior to fecal coliform sampling.
2. Duplicate sample.

6.4 Habitat Assessment

Habitat assessment scores were calculated from data collected in spring of 2002 (see Table 17). All six stations on Dardenne Creek were assessed as well as the two stations on North Fork Cuivre River (also in the same EDU as Dardenne Creek). When compared to NFCR, all six of the Dardenne Creek stations' scores were within 75% of the reference station scores and, therefore, high enough to potentially support a similar biological community.

Table 17
Habitat Assessment Scores

North Fork Cuivre River	Habitat Score		Dardenne Creek	Habitat Score	% of Mean Reference
Station 1	138		Station 1	137	99%
Station 2	137		Station 2	133	96%
			Station 3	135	98%
			Station 4	125	90%
			Station 5	137	99%
			Station 6	122	88%
Mean Reference Stream Score	138				

6.5 Estimates of Benthic Fine Sediment

The percentage of benthic fine sediment was measured at each sample station on Dardenne Creek and North Fork Cuivre River in July of 2002 (see Table 18). One sample station on Dardenne Creek, Station 6, contained only isolated pools and no discharge, so no measurement of sediment was taken. At Station 5, there were only two riffle-pool complexes present in the sample reach that were appropriate for estimating benthic fine sediment. Measurements from these two complexes were averaged to estimate benthic fine sediment within the reach. Dardenne Creek Station 1 contained only one riffle-pool complex within the reach. The majority of the sample reach was one long contiguous pool that was inappropriate for estimating benthic fine sediment, so only one transect grid was used to estimate fine sediment at Station 1. At North Fork Cuivre River Station 2, only two riffle-pool complexes were present to estimate fine sediment, so these two complexes were used to calculate an average for the reach.

At Dardenne Creek, the percentage of benthic fine sediment ranged from 23.3 up to 100%. The headwater stations in the creek contained less benthic sediment and the trend was that sediment generally increased as samples were collected downstream. The bedrock-laden stream reach at Station 5 yielded benthic sediment of 23%, while approximately 70% of the streambed at Stations 2, 3, and 4 was covered by fine sediment. The station located farthest downstream on Dardenne Creek had 100% coverage of the streambed by fine sediment.

At North Fork Cuivre River, the trend was reversed from the Dardenne Creek estimates. The highest fine sediment estimate was found at the upstream sample reach at Station 2 (67%). This amount was considerably higher than the 11% measured in the reach at Station 1. The sediment found at the upstream station on North Fork Cuivre River was comparable to the amounts of sediment estimated at Stations 2, 3, and 4 on Dardenne Creek. However, there was a great difference found between the stations located farthest downstream on these two waterbodies. The streambed at North Fork Cuivre River Station 1 was largely cobble and gravel, in contrast to Dardenne Creek Station 1 with its sandy stream bottom.

Table 18
Percentage of Benthic Sediment Observed per Grid-Quadrat and Station on Dardenne Creek and North Fork Cuivre River, July 2002

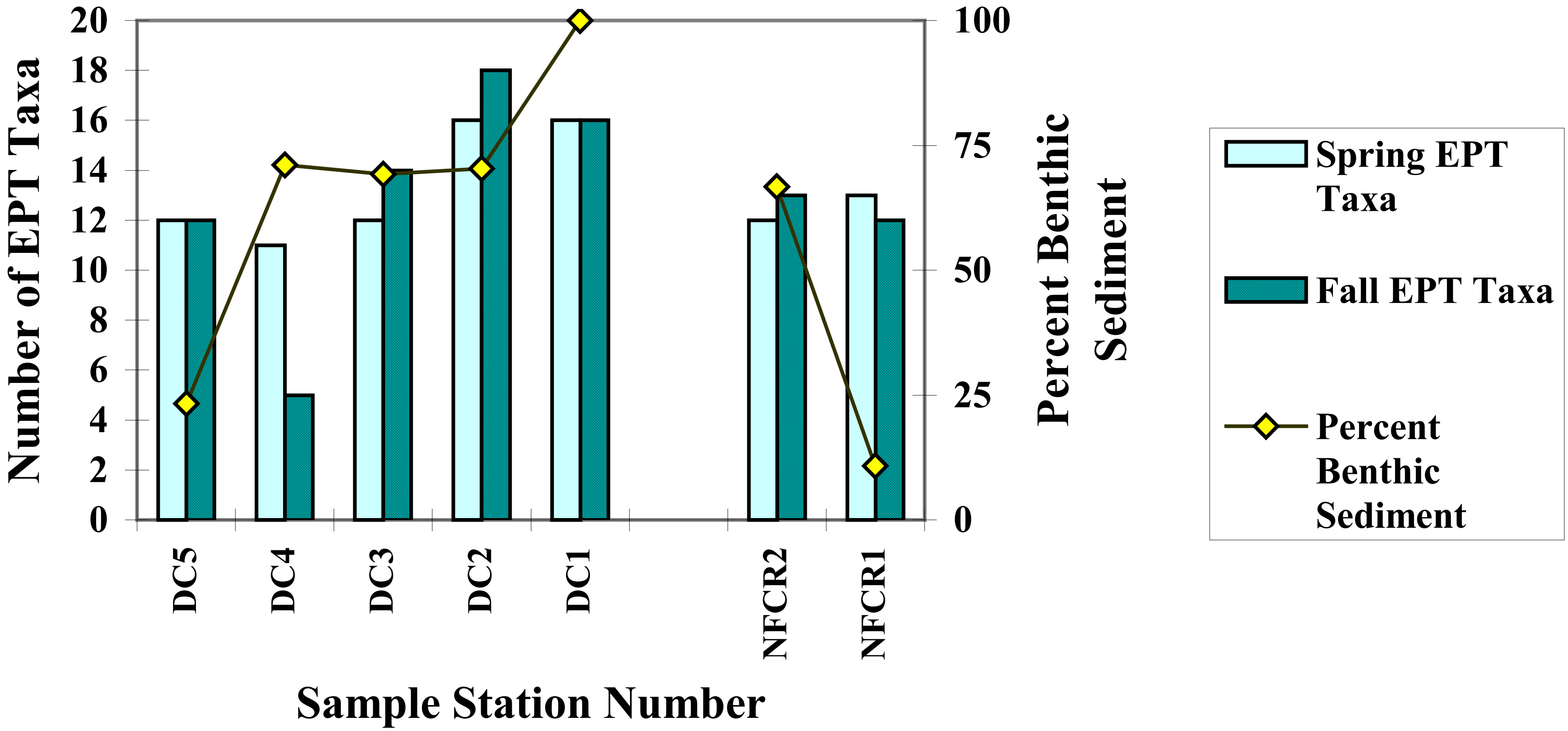
Grid No.-Quadrat No.	Dardenne Creek 5	Dardenne Creek 4	Dardenne Creek 3	Dardenne Creek 2	Dardenne Creek 1	N Fk Cuivre River 2	N Fk Cuivre River 1
1-1	0	30	95	45	100	90	55
1-2	0	45	90	100	100	100	30
1-3	15	25	30	100	100	100	15
1-4	0	40	65	65	100	100	0
1-5	25	100	90	35	100	80	10
1-6	10	15	35	100	100	100	15
2-1	15	100	100	80	----	90	5
2-2	80	100	100	5	----	5	5
2-3	15	100	0	15	----	0	5
2-4	15	100	0	85	----	5	20
2-5	90	100	100	5	----	30	0
2-6	15	5	0	30	----	100	15
3-1	----	100	100	100	----	----	5
3-2	----	95	100	100	----	----	5
3-3	----	45	100	100	----	----	5
3-4	----	95	40	100	----	----	0
3-5	----	100	100	100	----	----	0
3-6	----	85	100	100	----	----	5
Average	23.3	71.1	69.2	70.3	100	66.7	10.8

With regard to macroinvertebrate composition in relation to percent benthic fine sediment in Dardenne Creek, one trend emerged. In both field seasons, the highest numbers of EPT Taxa were collected at Stations 1 and 2, stations with higher percentages of benthic fine sediment (see Figure 10).

6.6 Quality Assurance/Quality Control (QA/QC) Results

Duplicate macroinvertebrate samples were collected during both sample seasons and shown in Table 19. In the spring, duplicate samples were collected at Station 1 on North Fork Cuivre River. The Quantitative Similarity Index (QSI) value was calculated between the two samples, and the index value of 87% was considerably above 65%, reflecting that the communities in both samples were quite similar. Two sets of duplicate samples were collected in the fall, one at North Fork Cuivre River Station 1 and one at Dardenne Creek Station 4. Both duplicate samples

Figure 10: Percent Benthic Sediment vs. Number of EPT Taxa, Dardenne Creek and North Fork Cuivre River



in the fall showed greater variability, reflecting a greater difference in the biological communities collected at the sample stations. However, QSI values at these two sample stations were still greater than 65%, thus insuring that sample methodology did not bias or affect the samples that were collected.

Table 19
Quantitative Similarity Index (QSI) Values for
Duplicate Macroinvertebrate Samples on North Fork Cuivre River (NFCR)
and Dardenne Creek (DC)

Station	Season	TT	Score	EPT	Score	BI	Score	SDI	Score	Total Score	QSI
NFCR 1a	Spring	73	3	13	3	6.69	3	2.83	3	12	87.2
NFCR 1b	Spring	72	3	12	3	6.77	3	2.93	3	12	
NFCR 1a	Fall	79	3	12	3	7.52	3	3.23	5	14	75.4
NFCR 1b	Fall	76	3	14	3	7.3	3	3.29	5	14	
DC 4a	Fall	49	3	5	1	7.74	3	2.95	3	10	78.2
DC 4b	Fall	53	3	6	1	7.51	3	3.08	3	10	

Duplicate water quality samples were also collected in both sample seasons and the results of the analyses are listed in Table 20. In the spring, a duplicate water sample was collected at Station 1 on North Fork Cuivre River. In the fall, there were two sets of duplicate samples collected, one at Station 1 of North Fork Cuivre River and one at Station 4 of Dardenne Creek.

Table 20
Water Quality Results from Duplicate Water Samples

Station	Season	Parameter					
		NH_3-N	NO_3+NO_2-N	TKN	Cl	TP	NFR
North Fork Cuivre River 1a	Spring	<0.05*	1.73	0.51	27.0	0.11	18
North Fork Cuivre River 1b	Spring	<0.05*	1.73	0.63	27.0	0.10	14
North Fork Cuivre River 1a	Fall	<0.05*	0.12	0.50	14.6	0.13	-----
North Fork Cuivre River 1b	Fall	<0.05*	0.12	0.70	14.8	0.13	-----
Dardenne Creek 4a	Fall	<0.05*	0.06	0.32	9.24	0.06	-----
Dardenne Creek 4b	Fall	<0.05*	0.05	0.47	9.17	0.07	-----

7.0 Discussion

7.1 Biological Assessment

7.1.1 Dardenne Creek Longitudinal Comparison

A few general trends emerged in the macroinvertebrate samples among the Dardenne Creek stations. There was a greater number of Total Taxa and EPT Taxa at the downstream sample stations (1 and 2) than the upstream stations (above 3). Also, the dominant family during both sample periods was the Chironomidae, except for the fall samples at stations 5 and 6 (they were the second most common family found at those stations). There were no known point sources on Dardenne Creek or the tributaries above the sample stations that might cause this change in number or composition of the macroinvertebrates.

The most noticeable difference among the Dardenne Creek samples was the sharp drop in both Total Taxa and EPT Taxa at Station 4 (and Station 3 in the spring sample). A large tributary, Little Dardenne Creek, enters into Dardenne Creek between Stations 4 and 5 and may have caused an impact to the number of taxa at the stations immediately downstream from the junction of these two streams. However, the decrease in taxa between stations occurred whether the discharge was high (spring) or low (fall). There were no known sources of pollution to attribute to this decrease in taxa. None of the Dardenne Creek sample reaches were in areas where construction or development was occurring, so best management practices could not be evaluated.

Seasonal differences between the samples on Dardenne Creek were reflected largely in the composition of the macroinvertebrates. In the spring, members of the family Chironomidae comprised at least 74% of the samples and members of the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) comprised only 2-13% of the samples. In the fall, Chironomidae comprised only half of the samples at three stations, while the percent EPT comprised 4-37% of all samples. Over all, diversity in the fall samples increased dramatically. Other than a difference in flow, there was no apparent reason for the change in macroinvertebrate composition and increase in diversity.

7.1.2 Dardenne Creek versus Control and Reference Streams

There was more urban influence within the watershed at Dardenne Creek than at either North Fork Cuivre River or South River, and this influence may have had an impact on the macroinvertebrate community. Although there was some variation in numbers of Total and EPT Taxa between sample stations on Dardenne Creek and North Fork Cuivre River in the spring, all Dardenne Creek sample stations produced significantly lower percentages of EPT taxa and higher percentages of Chironomidae in the samples than the North Fork Cuivre River stations.

The fall macroinvertebrate samples at Dardenne Creek 4, 3, and 1 also produced higher percentages of Chironomidae than on North Fork Cuivre River or South River. Dardenne Creek Stations 6, 5, and 2 and both North Fork Cuivre River sample stations produced comparable percentages of Chironomids that were lower than the other stations, while South River produced a far lower percentage of Chironomids in its sample. Dardenne Creek Stations 5 and 6 and South River 1 samples in the fall were the only stations at which the dominant family was not Chironomidae. With the exception of Dardenne Creek Station 4, all the Dardenne Creek stations had comparable or higher percentages of EPT taxa in their samples. At South River 1, 57% of the macroinvertebrate sample was comprised of EPT Taxa. It was not clear whether the difference in watershed land use or lack of flow/isolation of pools at Dardenne Creek Stations 3, 4, 5, and 6 contributed to the differences in the community composition between all the sample stations.

7.2 Physicochemical Data

7.2.1 Dardenne Creek Longitudinal Comparison

Results from the water quality samples did not exhibit any strong trends among the Dardenne Creek samples. Certainly, the difference in seasonal discharge at each station exerted some significant impacts upon both the macroinvertebrate communities and the water chemistry. In spring, conductivity generally increased as samples were collected downstream, however, the increase was not great. Turbidity, NO_3-N, TKN, Cl, and NFR concentrations also displayed the trend of increased concentrations at downstream stations. This increase may have been a result of increased spring discharge carrying an influx of debris and sediment from the watershed and the contribution from tributaries to Dardenne Creek. This larger influx of material into the downstream areas of the creek was available to sustain a higher population of invertebrates than at the upstream stations.

One exception to the elevated concentrations and measurements in spring was the lower turbidity, TKN, Cl, TP, and NFR concentrations and higher conductivity measurement at Station 2. The results at this station appear to be related to discharge and can be explained by the timing of the sample collection. Samples were collected at Station 2 three days after rainfall had occurred, while samples at all other Dardenne Creek stations were collected either in between storm events or just two days after rainfall. Measurements at this station were collected at a time of decreasing flow and heterotrophic inputs from the watershed, so the concentrations were lower than those collected at the other stations.

In the fall there were fewer apparent trends in the water quality measurements. Dissolved oxygen measurements were lower in all fall samples than in spring. This condition was probably due to higher water temperatures and increased oxygen demand in the stream caused by the death of algae, aquatic macrophytes, and other organisms. All conductivity measurements were higher in the fall and were the opposite of what was found in the spring; higher readings were found at the upstream stations on Dardenne Creek. One possible reason might be that the

upstream sample stations had lower flows and were isolated, resulting in evaporation and little chance of dilution from flow and/or tributary inputs. TKN, however, mimicked the spring samples when concentrations of TKN generally increased at downstream stations, but this was a small increase. There was one parameter that stood out in the fall samples, that of the Cl concentration of 52.8 mg/L at Dardenne Creek 6. It was at least three times the Cl samples collected at any other station. It was not clear whether this high Cl sample was due to evaporation or a contribution from the watershed.

7.2.2 North Fork Cuivre River Longitudinal Comparison

Among the two North Fork Cuivre River samples stations, flow measurements, conductivity, and dissolved oxygen measurements were similar and reflected the same seasonal trends found at Dardenne Creek. Spring conductivity measurements were lower than those in the fall, while dissolved oxygen measurements were higher in the spring. Spring concentrations of TKN decreased from the upstream station to the downstream station and there were no strong differences in the remaining nutrient and turbidity measurements on North Fork Cuivre River. Fall nutrient concentrations were considerably more variable than the spring concentrations. Concentrations of TKN, TP, and turbidity were lower at North Fork Cuivre River Station 2 than at Station 1, but concentrations of NO_3-N and Cl were higher at Station 2 than Station 1. Turbidity at Station 1 was almost twice the amount measured at Station 2 (a reverse of the spring measurement). This finding could be attributed to the increase in discharge found between North Fork Cuivre River Station 2 and 1 in the fall (0.15 cfs and 1.69 cfs, respectively). There were five known tributaries that entered into the river between Station 2 and Station 1.

Another noticeable difference in nutrient concentrations was in the fall NO_3-N concentrations. Although in spring there were slightly lower concentrations at Station 1 than at Station 2, by the fall season there was almost a six-fold increase from Station 1 to Station 2. It is not known why the input at Station 2 was so high, and the loss of NO_3-N between the two stations may have been caused by plant uptake or chemical reduction. At both stations, NO_3-N concentrations were greatly reduced in the fall from the spring values. This may have been due to increased uptake by plants and algae in the summer. Additional samples would be needed to determine the reason for the differences.

7.2.3 Dardenne Creek versus Control and Reference Streams

A comparison of the physicochemical measurements between Dardenne Creek and the two reference streams, North Fork Cuivre River and South River, revealed some significant differences. Discharge at North Fork Cuivre River sample stations in the spring was approximately the same as the discharge measured at the upper Dardenne Creek stations (5 and 6). In the fall, however, when all but the downstream two stations on Dardenne Creek either had no measurable flow or were isolated pools, discharge on North Fork Cuivre River was higher than both Dardenne stations. Discharge in the fall at South River was much greater than that

measured at Dardenne Creek and in between the measurements taken at North Fork Cuivre River.

During both seasons, conductivity and dissolved oxygen measurements were slightly higher at North Fork Cuivre River stations than on Dardenne Creek. Spring samples of turbidity, TKN, TP, and NFR at North Fork Cuivre River Stations 1 and 2 yielded concentrations that tended to fall within the upper range of concentrations measured on Dardenne Creek. Concentrations of Cl on North Fork Cuivre River were almost double of those measured at Dardenne Creek. The most significant difference in the spring samples was the extremely high NO_3-N concentrations found in the North Fork Cuivre River samples. These readings were over three times the highest concentrations in Dardenne Creek samples. Although the land use within the North Fork Cuivre River watershed is largely agricultural, it is not clear what the cause is for these elevated NO_3-N concentrations, (input of livestock waste, fertilizer runoff from row crops, etc.).

Fall samples were more variable between all sample stations and fewer trends emerged. Concentrations of TP in samples collected at North Fork Cuivre River fell in between the ranges of concentrations measured in Dardenne Creek samples. Turbidity and TKN concentrations differed between North Fork Cuivre River stations and Dardenne Creek. Turbidity at the upstream sample station on North Fork Cuivre River was comparable to some of the higher values measured on Dardenne Creek. The downstream sample station on North Fork Cuivre River measured a turbidity that was greater than 1.5 times the turbidity at any of the other stations. This might have been due to localized rainfall in the watershed; flow measured at the downstream sample station was considerably higher than the upstream station in the fall (over ten times the discharge measured at Station 1). The concentration of TKN at North Fork Cuivre River Station 2 was within the range of concentrations measured on Dardenne Creek, but the amount measured from the sample at North Fork Cuivre River Station 1 was considerably higher than any samples collected on Dardenne Creek.

In contrast, concentrations of NO_3-N and Cl were elevated at Station 2 on North Fork Cuivre River compared to Dardenne Creek samples, while North Fork Cuivre River Station 1 samples were either comparable to or slightly elevated above Dardenne Creek samples. Cl samples were 1.5 to 2 times higher at Station 2 than either Station 1 on North Fork Cuivre River or stations on Dardenne Creek. Like the spring samples, fall NO_3-N concentrations provided the largest difference in the water chemistry measurements. North Fork Cuivre River Station 2 yielded an NO_3-N concentration over ten times the concentrations measured in Dardenne Creek, and even six times more than the downstream sample on North Fork Cuivre River. Although it is apparent that there is a source of NO_3-N contributing to samples collected on the North Fork Cuivre River, the higher discharge at Station 1 inferred that dilution may have caused the decrease in the NO_3-N concentrations between Stations 2 and 1.

Measurements taken at South River in the fall of 2002 were a bit higher than most of the Dardenne Creek samples, but less than both of the North Fork Cuivre River samples. Turbidity, conductivity, dissolved oxygen, and TP concentrations were in between measurements from

Dardenne Creek and lower than North Fork Cuivre River. South River concentrations of Cl were higher than all other Cl concentrations (with the exception of the reading from Dardenne Creek 6). NO_3-N concentrations were higher at South River than at Dardenne Creek, but fell in between the concentrations measured at North Fork Cuivre River. TKN concentrations at South River fell far short of all other TKN measurements, even falling below the limits of detection. Because NH_3-N concentrations were also found to be below the limits of detection, these measurements infer that the primary form of nitrogen in the South River sample was NO_3-N. Although greater than 85% of the land use in the watershed was agricultural, there was insufficient information to determine whether it was the land use that contributed to this elevated NO_3-N concentration.

7.3 Fecal Coliform Samples

Although fecal coliform samples were collected several times throughout the months of July, August, and September at both Dardenne Creek and North Fork Cuivre River, these streams are not regulated for fecal coliforms within the sample reaches. Per the Missouri Water Quality Standards, streams are regulated for the presence of fecal coliform bacteria if the designated use for all or a part of the stream is "whole body contact" (Water Quality Standards, 2000). Only North Fork Cuivre River has this designation anywhere along it's length, and the reach of the river that is regulated for this parameter is downstream approximately a mile from the downstream sample station, Station 1. A comparison is given below as a general indicator of stream water quality.

Fecal coliform samples collected in July, August, and September on Dardenne Creek did not really exhibit any strong patterns. There were three sample dates when the samples at all three sample stations exceeded the criteria for beneficial use of 200 colonies per 100 milliliters of water. All stations exceeded the criteria at least once, and Stations 1 and 5 exceeded the criteria twice. There were no permitted discharges allowed to Dardenne Creek, however, there were numerous homes and agricultural operations located in the watershed that may have contributed to the presence of these organisms.

At North Fork Cuivre River, the frequency of occurrence of fecal coliform bacteria in the samples increased dramatically and the number of colonies increased per sample compared to those collected on Dardenne Creek. At both stations on North Fork Cuivre River, over half of the samples contained fecal coliform bacteria in excess of the 200-colony limit. Station 2 had higher numbers of colonies than Station 1 and all of the samples collected on North Fork Cuivre River had considerably higher numbers of colonies than those collected on Dardenne Creek (with the exception of one sample collected at Station 5). North Fork Cuivre River exhibited a higher number of fecal coliform bacteria and elevated nutrient and conductivity measurements compared to Dardenne Creek. Row crop and pasture are the predominate land use categories in the watershed and cattle grazed upstream of the sample reach at Station 1. Additional samples are needed to determine the cause(s) for the elevated parameters found on North Fork Cuivre River.

7.4 Habitat Assessment Scores

Habitat was assessed at both Dardenne Creek and North Fork Cuivre River sample reaches in the spring of 2002. Most of the stations on Dardenne Creek came within 90% of the mean of the scores from the two reference reaches on North Fork Cuivre River. Two reaches encompassing Dardenne Creek Stations 4 and 6 had more categories of the assessment that rated suboptimal, marginal, or poor. Ratings for the categories of bank stability, vegetative protection on the banks, and depth of riparian vegetation for both of these reaches indicated the condition of the watershed/stream interface. Some 30-100% of the stream banks at these stations were moderately to severely unstable, 50-69.9% of the stream banks lacked vegetation, and riparian depth was only 6-11.9 meters deep. These conditions may have contributed to the reach becoming unstable, the loss of sediment from erosion, and the movement of bank and substrate materials into and out of each of the reaches. This would, in turn, have a dramatic effect upon the macroinvertebrate community. The habitat at these stations may have contributed to the low stream condition index scores at Stations 4 and 6, among the lowest scores of the study (see Tables 6 and 7). The reach at Station 6 was comprised of bedrock shelves and outcroppings, particularly toward the downstream end of the reach, that may also have affected the macroinvertebrate community.

7.5 Benthic Sediment Assessment

Like the watershed and within-stream habitat assessment, the amount of benthic fine sediment in the stream could have an impact upon the ability of macroinvertebrates to colonize a reach of fine sediment (versus colonization of bedrock substrate). It could also influence what macroinvertebrate families, genera, and species inhabited a reach. The analysis of variance between the mean values of benthic sediment for each sample reach yielded several significant differences.

Among Dardenne Creek stations, there were significant differences in the percent benthic sediment between Station 5 and Stations 1 and 4 (see Appendix C). The sample reaches at Dardenne Creek Stations 1 and 4 had much higher percentages of benthic fine sediment than the reach at Station 5. The most significant difference between stations was found between Station 1 and Station 5 ($p<0.001$). Bedrock shelves, boulders, and cobble were common in the upstream reaches of Dardenne Creek (Stations 5 and 6), and this was reflected in a lower percentage of fine sediment. Although only one sediment grid was used to estimate benthic sediment at Dardenne Creek 1, visual observations of the reach supported the findings of the single grid measurement. Fine sediment was more common at this station than at the upstream reaches.

At the North Fork Cuivre River, a significantly higher estimate of fine benthic sediment was found at Station 2 than at Station 1. In the Station 2 reach, there were smaller beds of gravel and pools with fine sediment. At the reach including sample Station 1, a change in gradient occurred and the river cut through a number of boulders, cobble, and gravel substrate and there were fewer pools in the reach.

A comparison of benthic sediment between North Fork Cuivre River and Dardenne Creek revealed that North Fork Cuivre River Station 1 had the lowest percentage of benthic sediment in the study. This station produced significantly less sediment than Dardenne Creek Stations 1-4. Although the mean percent sediment at North Fork Cuivre River 2 was lower than the sediment measured at Dardenne Creek Stations 1-4, it was not significantly so.

8.0 Summary and Conclusions

No construction was occurring along the sample reaches of Dardenne Creek during the sample collection period, therefore, no Best Management Practices (BMPs) could be evaluated. The null hypotheses for this study were altered to reflect this finding. The study was modified to examine whether there were any differences among macroinvertebrate assemblages, water chemistry, fecal coliform concentrations, percent benthic sediment, and habitat quality between sample stations on Dardenne Creek. The study also examined whether there were differences in these parameters collected at Dardenne Creek and the control and biocriteria reference sites, North Fork Cuivre River and South River.

During both sample seasons, Dardenne Creek Stations 1 and 2 produced more EPT Taxa and/or Total Taxa, lower BI scores, and higher SDI scores than the upstream stations. In both seasons, conditions at these two stations, along with Station 5, were sufficient to partially, or fully, sustain their aquatic communities (see Figure 7). There were no notable findings in the water chemistry samples, fecal coliform samples, or habitat assessments at Stations 1 and 2 that may have contributed to the SCI scores. The greater amount of fine sediment in the reaches at these stations may have contributed to a higher number of organisms and differences in the taxa collected at the stations. It did not appear that the sediment was present due to development in the watershed since these two stations had the lowest amount of development and the highest percentage of forest in their watersheds.

The upstream stations indicated that impacts to the macroinvertebrate community are occurring, however, the source(s) of the impacts is not clear. The number of taxa and diversity decreased in the upstream stations, regardless of season. Again, there were no significant findings in the water chemistry samples, fecal coliform samples, or habitat assessments that pointed at any one causal element. Benthic sediment greatly decreased as samples were collected upstream and land use in the watershed shifted from forest to grassland and urban uses. Throughout the summer, discharge ceased at these stations, leaving isolated pools in the stream reaches and decreasing available habitat. This may be the cause of taxa decreasing from the spring to the fall samples at stations 4, 5, and 6.

Dardenne Creek Station 4 was noticeably lower in total and EPT taxa and had lower diversity and poorer biotic index scores. It was not clear what was effecting this reach of the stream. The land use in this reach had the highest percentage of urban development adjacent to the stream, and Little Dardenne Creek joins Dardenne Creek at the top of the reach. There were no permitted point-source discharges on Little Dardenne Creek, but no survey of that watershed was

conducted nor were any samples taken to determine whether it might be having an impact on Dardenne Creek.

The control and reference streams, North Fork Cuivre River and South River, generally produced metric values that were in between values found on Dardenne Creek. During both sample seasons, the control stream Total Taxa, EPT Taxa, BI scores, and SDI scores fell in between the better values measured at the downstream stations on Dardenne Creek and the lower or poorer values measured at the upstream stations. South River had fewer taxa and lower diversity than North Fork Cuivre River, but it did produce a higher biotic index score.

Water chemistry samples from the control stream, North Fork Cuivre River, provided an interesting contrast to the samples collected at Dardenne Creek. Cl and NO_3-N concentrations and turbidity measurements were higher at North Fork Cuivre River than at Dardenne Creek. Concentrations of NO_3-N at North Fork Cuivre River were two to three times the amount measured at Dardenne Creek. Also, the numbers of fecal coliform colonies were generally higher from the North Fork Cuivre River samples. Agricultural land use was prominent next to the river, particularly at Station 1, and it may be one factor causing the elevated measurements. South River, again, produced results that fell in between the concentrations found at Dardenne Creek and the control, North Fork Cuivre River.

The findings of this study revealed there were some clear differences in samples collected among the Dardenne Creek sites and between samples collected at Dardenne Creek and the control/ reference streams. As a result, all but one of the null hypotheses were rejected. Habitat assessments conducted at Dardenne Creek and North Fork Cuivre River were compared and the differences were insignificant. Therefore, the hypothesis concerning comparable habitat quality was accepted.

An examination of the water chemistry data, fecal coliform concentrations, habitat assessments, and percentage of benthic fine sediment provided information to help characterize impacts upon the macroinvertebrates found on Dardenne Creek, North Fork Cuivre River, and South River. According to the scores calculated from the metrics, the sample stations were impacted as follows:

1. No Dardenne Creek station exhibited fully sustaining SCI scores (>16) during the study.

2. Dardenne Creek Stations 1 and 2 consistently produced the highest SCI scores and appeared to be the least impacted areas sampled on that creek. The macroinvertebrate community exhibited either partial or full sustainability scores and provided an indeterminate assessment of the creek at these stations.

3. Dardenne Creek Station 3 was the only other station that exhibited different sustainability scores. However, the spring season was scored as non-sustainable, and resulted in an indeterminate assessment based on the irregular difference in scoring categories.

4. Dardenne Creek Stations 4, 5, and 6 had SCI scores in either partial or non-sustainable categories and demonstrated a consistent biological impairment during both sample seasons.

5. Dardenne Creek Station 4 is of special concern. The overall upward trend in SCI scores from upstream to downstream is not evident at this station. The scores reflected biological impairment and were the lowest of the Dardenne Creek stations.

6. Although Dardenne Creek Stations 5 and 6 showed consistent biological impairment, the assessments here were complicated by several years of very low rainfall, flow conditions, and the small stream size at these stations.

7. Both control stations on the North Fork Cuivre River exhibited impaired conditions, indicating that the sample reaches would only partially sustain macroinvertebrate communities. The sample reaches at Stations 1 and 2 had SCI scores lower than Dardenne Creek Stations 1 and 2, but higher than the other sample stations on Dardenne Creek.

8. The regional reference stream, South River, also indicated some impairment was present in the sample reach, therefore, only partially supporting the macroinvertebrate community. Like the North Fork Cuivre River, the SCI score was lower than the scores calculated at Dardenne Creek Stations 1 and 2, but higher than the remaining stations.

9.0 Recommendations

1. Collect macroinvertebrate, water chemistry, and sediment samples from the reaches at Dardenne Creek stations 1, 2, 3, and 5. Using these samples, determine whether the fluctuations in data are caused by natural conditions in the stream and watershed (rainfall, discharge, benthic substrate type, etc.) or anthropomorphic changes in the watershed.

2. Collect macroinvertebrate, water chemistry, and sediment samples from the reaches at Dardenne Creek stations 4 and 6. In addition, collect the same data from Little Dardenne Creek, at the tributary that enters into Dardenne Creek upstream of Dardenne Creek 4, and collect samples upstream and downstream of this tributary. Conduct a more thorough land use survey above the reaches at these two stations (and above Little Dardenne Creek) to ensure impacts from the watershed are considered.

3. Conduct additional macroinvertebrate and water chemistry sampling on North Fork Cuivre River to determine whether elevated nutrients are causing impacts to the macroinvertebrate community. Survey the watershed of these two reaches to determine whether land use is causing the increase in the nutrient concentrations and fecal coliform colonies. Also, collect water samples downstream of this sample reach, within the segment of the river that is regulated for full body contact beneficial use, to determine whether fecal coliform standards are exceeded.

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Missouri Department of Natural Resources. 2002e. Standard Operating Procedure MDNR-FSS-210: Quality Assurance/Quality Control for Environmental Data Collection. Air and Land Protection Division, Environmental Services Program, Jefferson City, Missouri. 12 pp.

Submitted by: ________________________________

Cecilia Campbell
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date: ________________________________

Approved by: ________________________________

Earl Pabst
Director
Environmental Services Program

CC:th

c: Mohamad Alhalabi, Regional Director, SLRO
John Ford, QAPP Project Manager, WPCP
Tod Hudson, WPCP
Sarah Oakes, Fisheries Biologist, MDC
Becky Shannon, WPCP
Mohsen Dkhili, WPCP

Appendix A

Study Plan

Missouri Department of Natural Resources

Assessment Study Proposal

Dardenne Creek, St. Charles County

January 18, 2002

Objectives

The Dardenne Creek watershed is predominately located in St. Charles County, Missouri with the headwaters originating in Warren County. The lower reach of this stream is located in a heavily developed urban area. The middle and upper reaches of the stream drain areas that are rural, but are quickly being consumed by development from urban sprawl. Dardenne Creek has been placed on the 303(d) list due to concerns related to that situation. These concerns include the potential for water quality degradation due to stormwater runoff and the likely detrimental effects of development on the stream channel and riparian areas. Therefore, we propose to conduct a macroinvertebrate bioassessment, chemical, and physical assessment of Dardenne Creek. Our objectives are to determine: 1) whether there is greater aquatic life impairment in the most urbanized portions of the creek relative to sections upstream of that area; 2) whether aquatic life in Dardenne Creek is impaired relative to that of regional reference streams; and 3) whether this stream is impaired due to nutrification and sedimentation by urban runoff.

Null Hypotheses

1) The macroinvertebrate assemblages will not differ between reaches of Dardenne Creek where best management practices (BMPs) are in use in the watershed and reaches where poor management practices are used in the watershed.

2) Water chemistry will not differ between reaches of Dardenne Creek where BMPs are in use in the watershed and reaches where poor management practices are used in the watershed.

3) Fecal coliform concentrations will not differ between reaches of Dardenne Creek where BMPs are in use in the watershed and reaches where poor management practices are used in the watershed.

4) Benthic sediment percentage estimates will not differ between reaches of Dardenne Creek where BMPs are in use in the watershed and reaches where poor management practices are used in the watershed.

5) Habitat quality will not differ between reaches of Dardenne Creek where BMPs are in use and where poor management practices are in use in the watershed.

6) Macroinvertebrate assemblages will not differ between Dardenne Creek and reference streams within the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers Ecological Drainage Unit (EDU).

7) Water chemistry will not differ between Dardenne Creek and reference streams within the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers Ecological Drainage Unit (EDU).

8) Fecal Coliform concentrations will not differ between Dardenne Creek and reference streams within the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers Ecological Drainage Unit (EDU).

9) Benthic sediment percentage estimates will not differ between Dardenne Creek and local and regional reference streams within the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers Ecological Drainage Unit (EDU).

10) Habitat quality will not differ between Dardenne Creek and reference streams within the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers Ecological Unit (EDU).

Background

Streams subjected to urban development are particularly vulnerable to water quality and habitat degradations. Water quality could be degraded by wastewater treatment plant discharges, accidental or deliberate spills, illegal dumping, and sedimentation due to increased runoff. Habitat losses often result from residential or commercial development. It is believed that the pace and extent of development in the area may threaten the biological integrity of Dardenne Creek, which flows through St. Charles County. This belief has prompted a joint effort between the Missouri Department of Natural Resources (MDNR) and the Missouri Department of Conservation (MDC) to determine the current status of Dardenne Creek. The MDC has collected water quality samples, fish community surveys, and habitat assessments at sites along Dardenne Creek. The MDNR and MDC will continue to collect water quality, bacteriological, and biological samples from the creek.

Study Design

General: The study area includes approximately 15 miles of Dardenne Creek. The upstream boundary of the Dardenne Creek study area is just upstream of the Holt Road Bridge, while the downstream boundary is just downstream of the Highway 70 bridge in St. Peters. Six Dardenne Creek stations will be surveyed, one/two in which BMPs are used in the watershed and four/five where poor management practices are in use. The general locations are listed in Table 1, beginning with the site located most downstream:

Table 1
Dardenne Creek Sample Locations

Sample Station	Geographic Location	Watershed Size (mi.^{2})
#1	August A. Busch Memorial Conservation Area	38
#2	sec. 21, T. 46 N., R. 2 E.	34
#3	sec. 17, T. 46 N., R. 2 E.	26
#4	Sur. 418, T. 46 N., R. 2 E.	28
#5	Sur. 1807, T. 46 N., R. 1 E.	16
#6	S ½ sec. 22, T. 46 N., R. 1 E.	9

Dardenne Creek is in a geologic and soil transition area where the Ozark/Moreau/Loutre EDU and the Plains/Mississippi Tributaries between Des Moines and Missouri Rivers EDU converge. Biological, chemical, bacteriological, and habitat comparisons will be made between the sample stations on Dardenne Creek and two sites on a local reference stream, North Fork Cuivre River. Data collected from this local reference stream will also be used in a companion study on nearby Peruque Creek. Biological, habitat, and limited chemical comparisons will be made between the stations on Dardenne Creek, North Fork Cuivre River, and three regional biocriteria reference streams.

Biological Sampling: Each macroinvertebrate station will consist of a length approximately 20 times the average stream width and will contain at least two riffle areas. To assess variability among sampling stations, stream discharge measurements, water quality samples, and habitat assessments will be taken during macroinvertebrate surveys. Sampling will be conducted during spring 2002 (March 15 through April 15) and fall of 2002 (September 15 through September 30).

Macroinvertebrates will be sampled in accordance with the guidelines of the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP). Dardenne Creek will be considered a "riffle/pool" dominated stream and samples will be collected from flow over coarse substrate, depositional (non-flow), and root-mat habitats. Each macroinvertebrate sample will be a composite of six subsamples within each habitat. Fish community surveys have also been conducted at each of the six sample sites and that data will be shared with MDNR.

Water Quality Sampling: Water quality samples will be collected on alternate weeks by MDC personnel from March 1, 2002 through September 30, 2002 at three stations on Dardenne Creek and two on North Fork Cuivre River. The samples will be collected per MDNR-FSS-001 (Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Considerations) and MDNR-FSS-002 (Field Sheet and Chain-of-Custody Record). All water samples will be analyzed for ammonia-nitrogen, nitrite and nitrate-nitrogen, total Kjeldahl nitrogen, total phosphorus, chloride, turbidity, and total and volatile suspended solids. Stream discharge measurements will also be taken at the time of sample collection (using a Marsh-McBirney flow meter and following the guidelines in MDNR-FSS-113, Flow Measurement in Open Channels).

In addition to the collection of water samples by MDC staff, MDNR water quality personnel will collect water samples at the time of each macroinvertebrate sampling event. These samples also will be collected per MDNR-FSS-001 (Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Considerations) and MDNR-FSS-002 (Field Sheet and Chain-of-Custody Record). The samples will be analyzed for ammonia-nitrogen, nitrite and nitrate-nitrogen, total Kjeldahl nitrogen, total phosphorus, chloride, and turbidity. Field measurements will be taken at the time of water sample collection and will include pH (per MDNR-FSS-100, Field Analyses of Water Samples for pH), conductivity (per MDNR-FSS-102, Field Analyses of Specific Conductance), temperature (per MDNR-FSS-101, Field Measurement of Water Temperature), dissolved oxygen (per MDNR-FSS-103, Sample Collection and Field Analyses for Dissolved Oxygen Using a Membrane Electrode Meter), and stream discharge using a Marsh-McBirney flow meter (per MDNR-FSS-113, Flow Measurement in Open Channels).

MDNR water quality personnel will collect water samples for fecal coliform analyses at three sites on Dardenne Creek and two sites on North Fork Cuivre River. Three replicate samples will be collected four times during this low flow period (July 2002–September 2002), at least two weeks apart. All samples will be collected and processed in accordance with MDNR-FSS-108 (Field Analysis of Fecal Coliform Bacteria).

MDC personnel will collect water samples twice during storm events. Samples will be collected immediately after rainfall events above one inch and analyzed by the MDNR Environmental Services Program (ESP) laboratory for volatile suspended solids and nonfilterable residues. MDNR personnel will also provide technical assistance to MDC personnel in the collection of these samples.

Benthic Sediment Percentage: To ensure uniformity in estimating the percentage of benthic sediment, depositional areas will be sampled instream at the upper margins of pools and lower margins of riffle/run habitat. Depths of the sample areas will not exceed two (2.0) feet and water velocity will be less than 0.5 feet per second (fps). A Marsh-McBirney flow meter will be used to ensure that water velocity of the sample area is within this range.

In-stream deposits of fine sediment [i.e. less than particle size of approximately 2mm, (coarse sand)] will be estimated for percent coverage per area. A visual method will be used to estimate the percentage of fine sediment. Three fine sediment sample areas (grids) will be set up at each water quality/macroinvertebrate sample site; the sample areas will consist of six contiguous transects across the stream. A tape measure will be placed directly on the substrate within each of the six transects using a random number that equates to one-foot increments. The trailing edge of the quadrat will be placed on the random foot increment. Two MDNR water quality personnel will estimate the percentage of the stream bottom covered by fine sediment within each quadrat. If estimated percentages are within ten percent between the MDNR personnel, it will be accepted. If estimates diverge more than ten percent, they will repeat the process until the estimates are within the acceptable margin of error. An average of these two estimates will be recorded and used for analysis.

Habitat Sampling: Stream habitat assessments were conducted by MDC personnel at each of the fish study sites following the Regional Environmental Monitoring and Assessment Program (REMAP) protocol in conducting the assessments.

Laboratory Methods: All water samples will be analyzed at the MDNR ESP laboratory. The samples of macroinvertebrates will be processed and identified per MDNR-FSS-209 (Taxonomic Levels for Macroinvertebrate Identification).

Data Recording and Analyses: Macroinvertebrate data will be entered in a Microsoft Access database in accordance with MDNR-WQMS-214 (Quality Control Procedures for Data Processing). Data analysis is automated within the Access database. Four standard metrics will be calculated for each sample reach according to the SMSBPP: Total Taxa (TT); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Index (SI). Additional metrics, such as Quantitative Similarity Index for Taxa (QSI-T) or Percent Scrapers (PS) may be used to discern differences in taxa between control and impacted stations.

Macroinvertebrate data will be analyzed in three specific ways. First, a comparison of metrics will be made between sample reaches on Dardenne Creek where best and poor management practices are in use. Data will be summarized and presented in bar graphs comparing means of the four standard metrics (and other biological parameters) among the six study reaches. Second, Dardenne Creek data will be compared to that collected at a local reference stream site (North Fork Cuivre River). Finally, both Dardenne Creek and North Fork Cuivre River data will be compared to historic and current data collected at three regional reference sites (North River, South River, and South Fabius River).

Ordination of macroinvertebrate data may be performed and regression analysis used to examine potential associations with water chemistry and habitat data. Habitat, fish community, and water quality data also will be used to help interpret macroinvertebrate data.

Water quality data will be entered in the Laboratory Information Management System (LIMS) database. Data analysis will be performed using Microsoft Access and Excel software as well as Jandel Scientific software, SigmaStat.

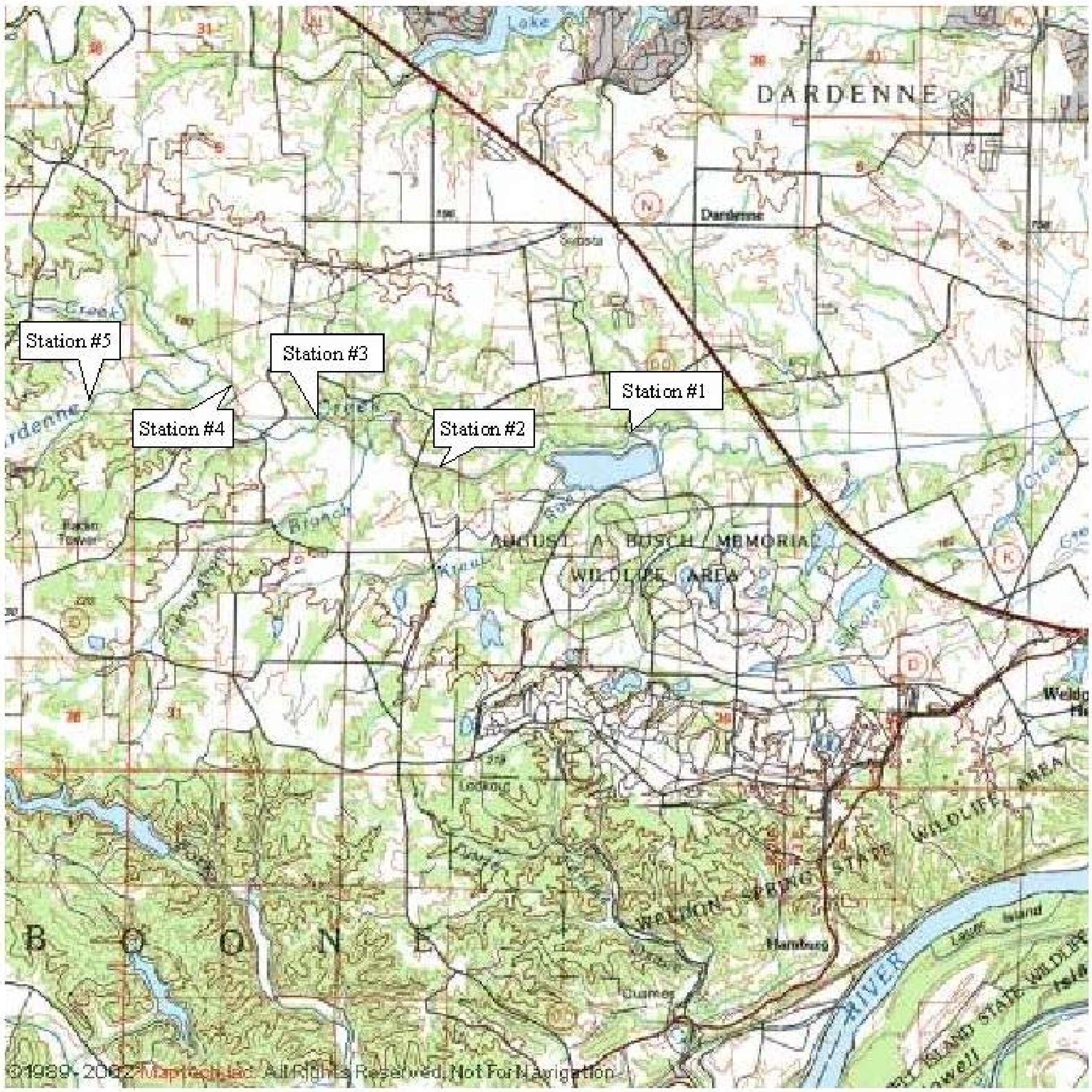
Data Reporting: Results of the study will be summarized, interpreted in report format, and delivered to the Biological Assessment QAPP Project Officer.

Quality Control: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

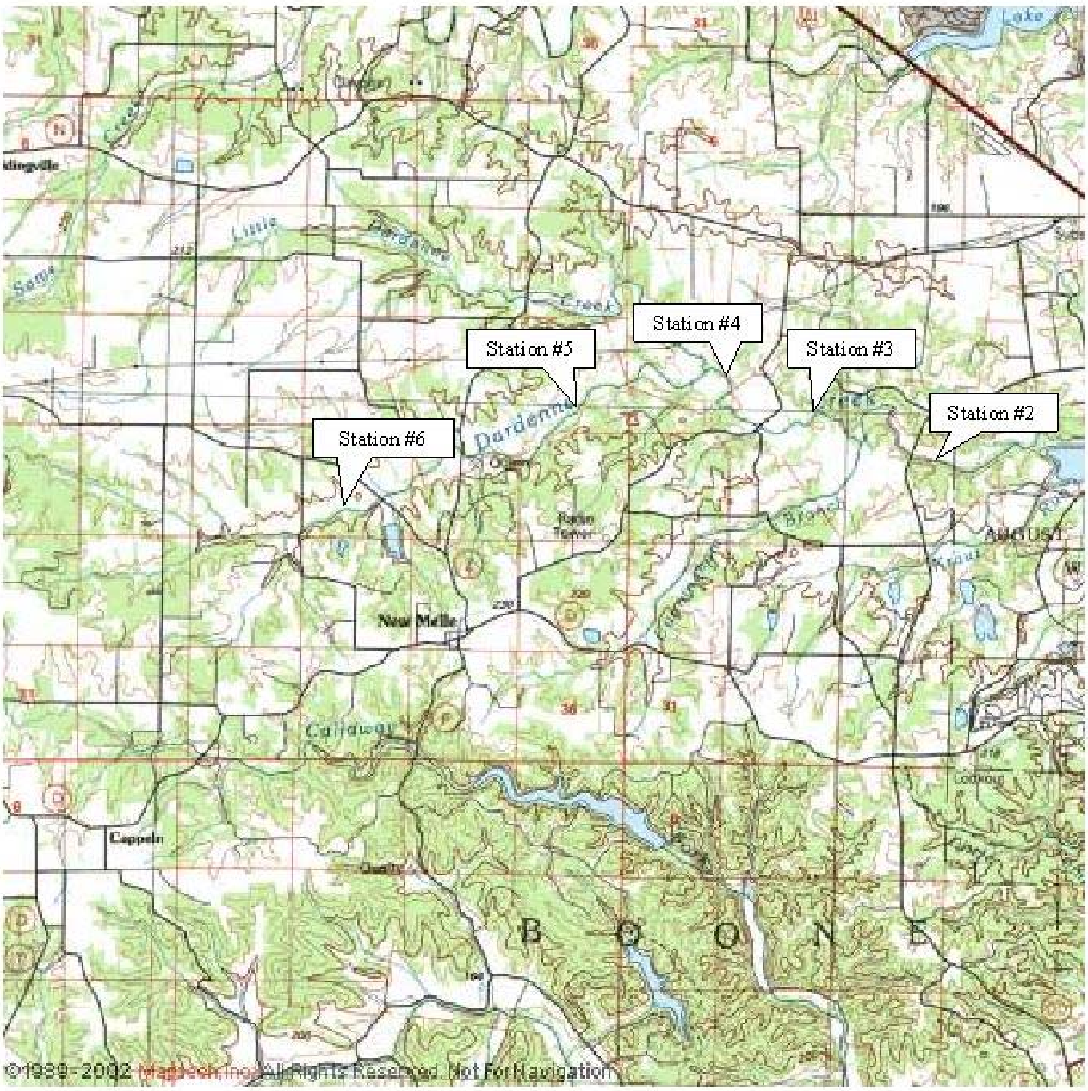
Attachments

Maps of Dardenne Creek sampling stations

Dardenne Creek
St. Charles County, Missouri
Downstream Sampling Stations



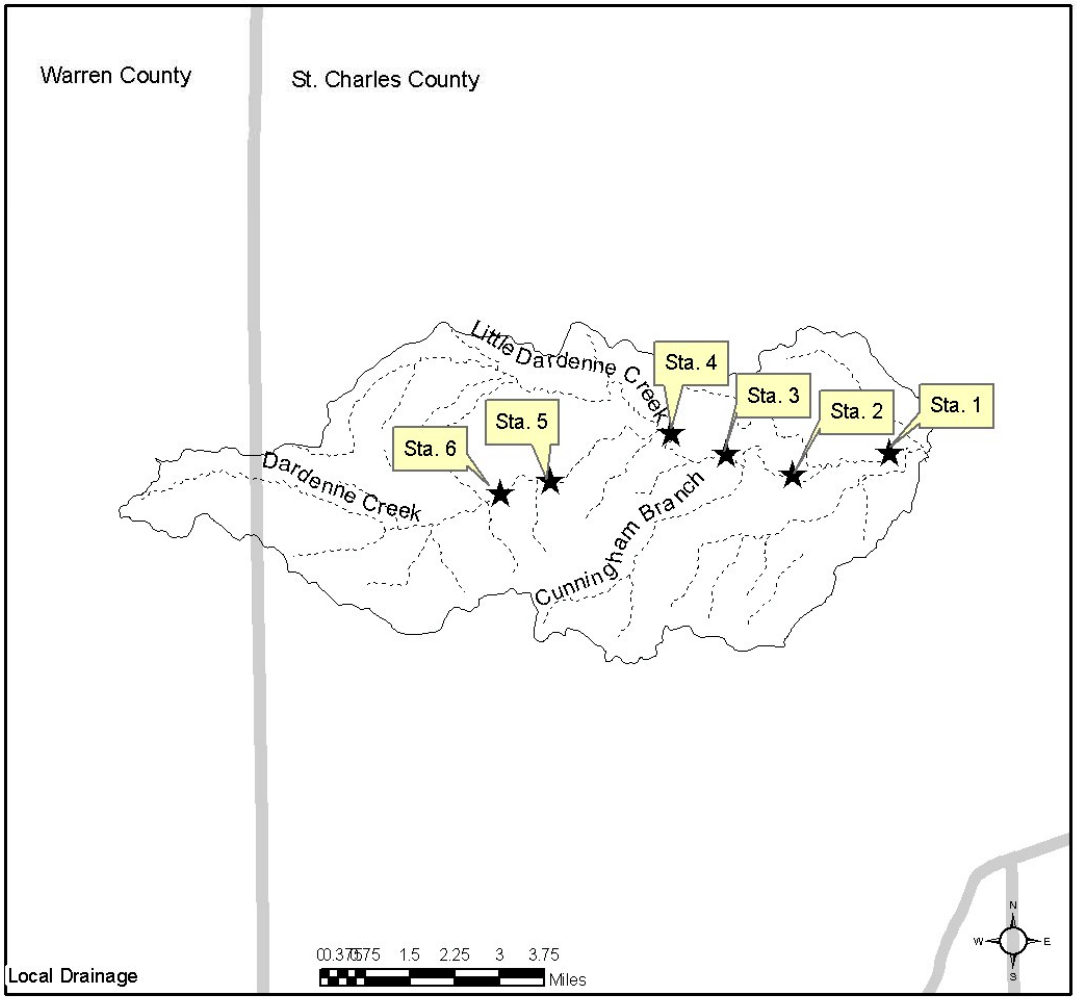
Dardenne Creek
St. Charles County, Missouri
Upstream Sampling Stations



Appendix B

Maps of Dardenne Creek, North Fork Cuivre River, and South River

Dardenne Creek Study Sample Stations



Sampling Location

County Boundary

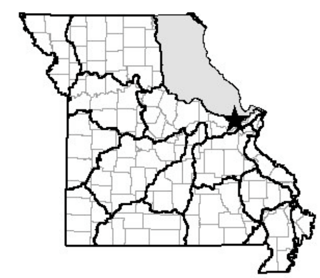
Local Drainage

Stream/River

Local Drainage and Biologic Sampling Site Location

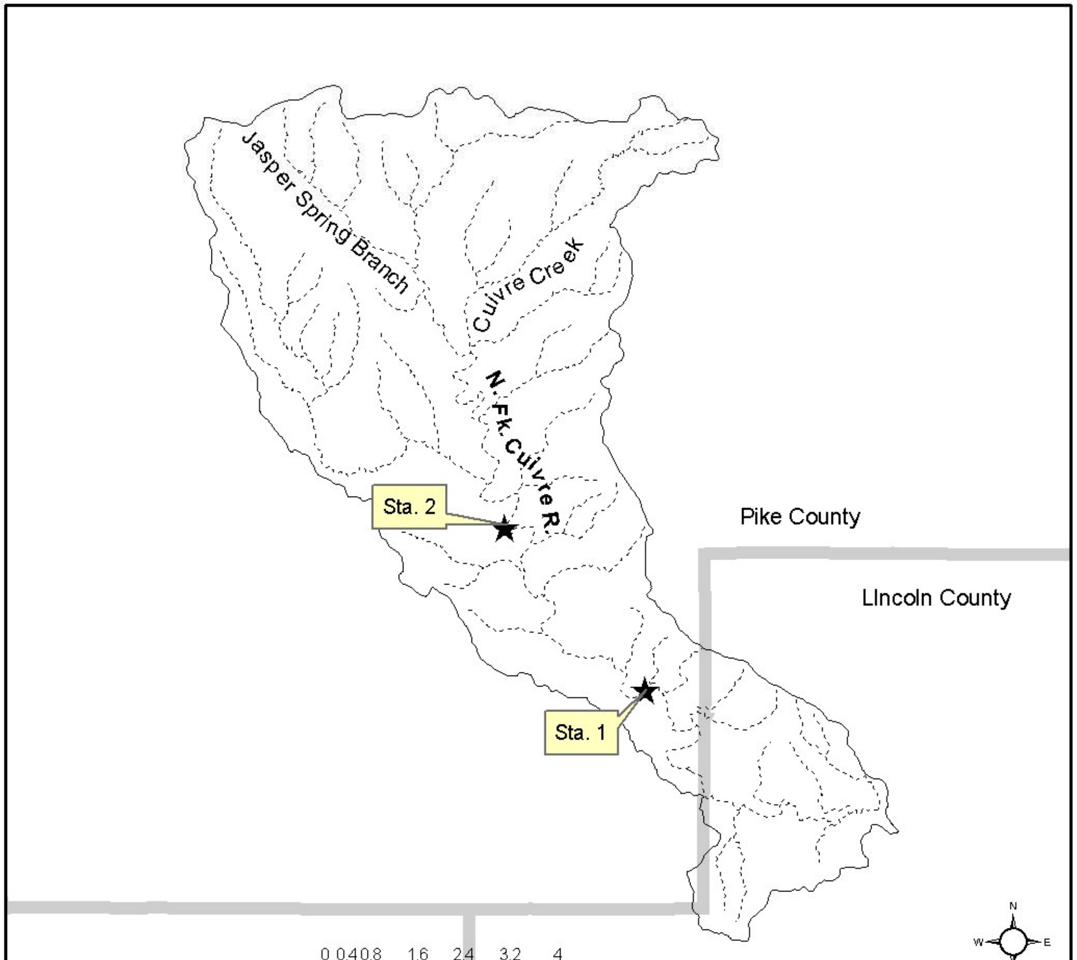
Ecolocial Drainage Unit (EDU) - An EDU is an area that contains a unique combination of habitats and organisms. Missouri is divided into 19 EDUs as shown in the inset map below. This site is located in the highlighted EDU.

Local Drainage - The local drainage area, also known as a 14 Digit Hydrologic Unit, is shown in the main map at left. This area is a portion of the local watershed. Missouri is split into over 1500 such units.



Ecological Drainage Unit

North Fork Cuivre River Sample Stations



Local Drainage

Sampling Location

County Boundary

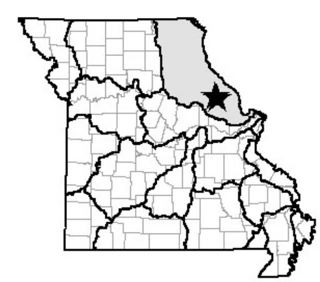
Local Drainage

Stream/River

Local Drainage and Biologic Sampling Site Location

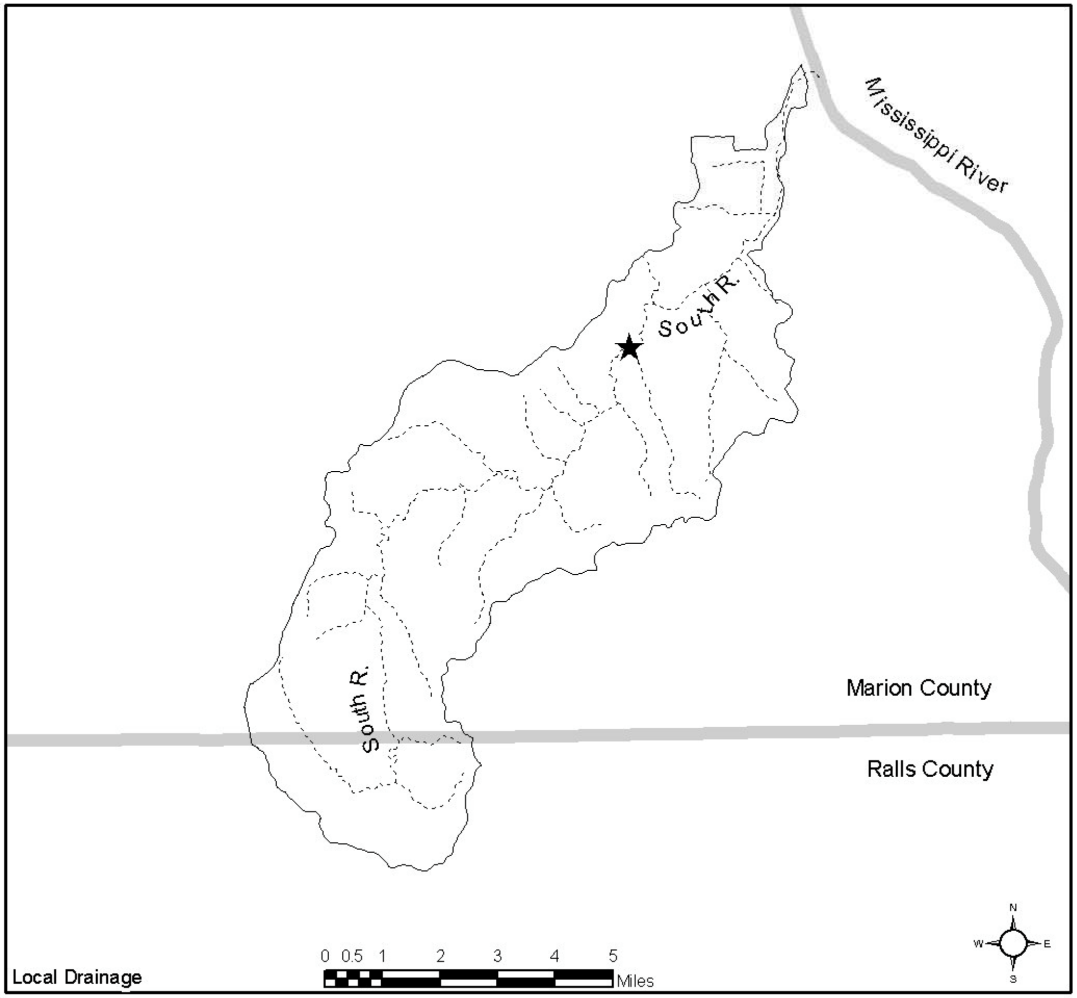
Ecolocial Drainage Unit (EDU) - An EDU is an area that contains a unique combination of habitats and organisms. Missouri is divided into 19 EDUs as shown in the inset map below. This site is located in the highlighted EDU.

Local Drainage - The local drainage area, also known as a 14 Digit Hydrologic Unit, is shown in the main map at left. This area is a portion of the local watershed. Missouri is split into over 1500 such units.



Ecological Drainage Unit

South River Sample Station



Local Drainage

★ Sampling Location

County Boundary

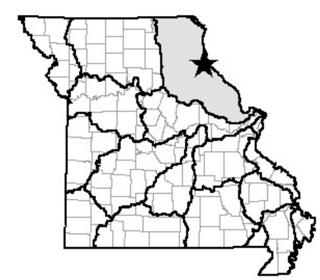
Local Drainage

Stream/River

Local Drainage and Biologic Sampling Site Location

Ecolocial Drainage Unit (EDU) - An EDU is an area that contains a unique combination of habitats and organisms. Missouri is divided into 19 EDUs as shown in the inset map below. This site is located in the highlighted EDU.

Local Drainage - The local drainage area, also known as a 14 Digit Hydrologic Unit, is shown in the main map at left. This area is a portion of the local watershed. Missouri is split into over 1500 such units.



Ecological Drainage Unit

Appendix C

List of Macroinvertebrate Taxa from Each Sample Station

Dardenne Creek Station 1, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Crangonyx			1
Hyalella azteca		3	44
Berosus		1	1
Dineutus			1
Dubiraphia	4	8	1
Gyrinus			1
Hydrobius		2	1
Peltodytes			3
Scirtes			2
Stenelmis	3		
Orconectes			1
Ablabesmyia		1	1
Ceratopogoninae	4	9	
Chironomus	1		
Cladotanytarsus	3	2	
Clinocera	4		
Clinotanypus		1	
Corynoneura	1	3	2
Cricotopus bicinctus		1	
Cricotopus trifascia			1
Cricotopus/Orthocladius	175	23	103
Cryptochironomus		2	
Dicrotendipes		1	
Diptera	1	2	
Endochironomus		1	1
Eukiefferiella brevicalcar grp	3		
Glyptotendipes		2	
Gonomyia	3	1	
Hexatoma			1
Hydrobaenus	346	86	65
Orthocladius (Euorthocladius)	13		1
Paratanytarsus		13	3
Paratendipes		4	
Pilaria	1		
Polypedilum convictum grp	2		
Polypedilum halterale grp		4	
Polypedilum illinoense grp			1
Procladius		1	
Prosimulium	1		1
Pseudosmittia	1		

Dardenne Creek Station 1, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Rheocricotopus	1		1
Simulium	14		18
Stictochironomus	1	9	
Tanytarsus	14	20	5
Thienemanniella			1
Thienemannimyia grp.	2		2
Tipula	Present, not counted		
Tvetenia	1		
Zavrelimyia			1
Caenis latipennis	15	22	10
Centroptilum		2	8
Leptophlebiidae		1	
Stenonema femoratum	2	1	
Ranatra fusca			Present, not counted
Physella			1
Lumbricidae	2		
Argia	Present, not counted	3	3
Basiaeschna janata			Present, not counted
Enallagma		11	3
Libellula		Present, not counted	
Nasiaeschna pentacantha			1
Progomphus obscurus		1	
Allocapnia	1		2
Amphinemura	3		2
Clioperla clio			1
Haploperla	3		
Hydroperla crosbyi	1		
Isoperla	5		4
Perlesta	5		
Chimarra	1		
Ironoquia			3
Mystacides		1	
Nyctiophylax		1	
Triaenodes			2
Branchiura sowerbyi		3	
Enchytraeidae	2	7	
Ilyodrilus templetoni	1		
Limnodrilus claparedianus	2		
Limnodrilus hoffmeisteri	6	3	1
Tubificidae	4	4	

Dardenne Creek Station 1, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Sphaerium		2	

Dardenne Creek Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina	1		
Crangonyx		1	6
Hyalella azteca			44
Berosus		2	1
Dineutus			2
Dubiraphia		2	7
Hydroporus			1
Optioservus sandersoni			1
Paracymus		1	
Peltodytes		2	
Orconectes virilis			Present, not counted
Ablabesmyia		1	4
Ceratopogoninae	8	10	5
Chaoborus		1	
Cladotanytarsus	1	3	
Corynoneura		3	6
Cricotopus bicinctus	2		
Cricotopus trifascia	5		
Cricotopus/Orthocladius	95	6	59
Dicrotendipes			3
Diptera			1
Eukiefferiella brevicalcar grp	4		1
Gonomyia	1	2	1
Hemerodromia	5	2	
Hexatoma	Present, not counted	1	
Hydrobaenus	344	184	158
Microtendipes			2
Orthocladius (Euorthocladius)	6		1
Parakiefferiella		2	
Parametriocnemus	2		
Paratanytarsus			12
Paratendipes		4	1
Phaenopsectra		2	1
Pilaria		1	
Polypedilum fallax grp			1
Polypedilum halterale grp	2		
Polypedilum scalaenum grp		1	
Prosimulium	10		
Pseudochironomus		1	
Simulium	12		

Dardenne Creek Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Stempellinella			4
Stictochironomus	1	5	
Sympotthastia	1		
Tabanus	Present, not counted	1	
Tanytarsus	10	6	14
Thienemanniella	3		
Thienemannimyia grp.	1		5
Tipula	Present, not counted		
Tvetenia bavarica grp	1		
Acerpenna	2		
Ameletidae			1
Caenis latipennis	8	7	51
Centroptilum			3
Leptophlebia			Present, not counted
Leptophlebiidae			1
Stenonema femoratum	2		Present, not counted
Caecidotea		8	
Caecidotea (Blind & Unpigmented)	1		
Ancylidae		1	1
Fossaria		1	
Physella			1
Lumbricidae		1	
Argia			7
Basiaeschna janata		Present, not counted	
Calopteryx			1
Enallagma			10
Epitheca (Tetragoneuria)			Present, not counted
Libellulidae			1
Allocapnia	5		
Amphinemura	14	1	
Chloroperlidae	1		1
Clioperla clio	1		
Isoperla	30		
Perlesta	11		
Perlidae	15		
Polycentropus	1		1
Triaenodes			2
Enchytraeidae	2	3	
Limnodrilus hoffmeisteri	1		
Tubificidae	1	4	1

Dardenne Creek Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Sphaerium		Present, not counted	

Dardenne Creek Station 3, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina			1
Crangonyx			2
Hyalella azteca			3
Dineutus			Present, not counted
Dubiraphia	1		
Ectopria nervosa	1		
Enochrus			2
Peltodytes		1	3
Scirtes			6
Tropisternus			Present, not counted
Orconectes			Present, not counted
Ablabesmyia			1
Ceratopogoninae	1	1	
Chaoborus		1	3
Cladotanytarsus	1		
Clinocera	Present, not counted		
Corynoneura	1	3	3
Cricotopus/Orthocladius	161	41	75
Cryptochironomus		1	
Diamesa	1		
Dicrotendipes		3	1
Diptera		1	1
Eukiefferiella		1	
Eukiefferiella brevicalcar grp	1	1	
Glyptotendipes		1	
Gonomyia	1		
Hexatoma	1		
Hydrobaenus	411	251	128
Orthocladius (Euorthocladius)	2		
Paratanytarsus			1
Paratendipes	2	3	
Phaenopsectra		3	1
Pilaria		2	
Polypedilum convictum grp			1
Rheocricotopus			1
Simulium	2		2
Stictochironomus		5	
Tanytarsus	2	6	1
Thienemannimyia grp.			1
Baetidae	1		

Dardenne Creek Station 3, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Caenis latipennis		1	
Centroptilum		1	3
Hexagenia		1	
Stenonema femoratum	1		1
Microvelia			1
Caecidotea	1		2
Macromia		Present, not counted	
Chloroperlidae	2		
Clioperla clio	Present, not counted		
Isoperla	4	1	
Perlesta	2		1
Perlinella drymo			Present, not counted
Ironoquia			1
Rhyacophila	1		
Enchytraeidae			7
Limnodrilus hoffmeisteri		2	

Dardenne Creek Station 4, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Crangonyx	Present, not counted		
Agabus			Present, not counted
Enochrus			1
Oreodytes		1	
Paracymus			1
Peltodytes			1
Orconectes virilis	Present, not counted		Present, not counted
Ceratopogoninae	12	1	1
Chaoborus	1		1
Chrysops		1	
Cladotanytarsus	3		
Clinocera	3	1	
Corynoneura		1	
Cricotopus trifascia	1		
Cricotopus/Orthocladius	115	21	27
Cryptochironomus	1		
Culex	1		
Dicrotendipes	2		
Diplocladius		1	1
Diptera	1		
Dixella			1
Eukiefferiella brevicalcar grp	6		
Gonomyia	7	4	
Hemerodromia	1		
Hexatoma	Present, not counted		
Hydrobaenus	428	239	233
Ormosia	1	3	
Orthocladius (Euorthocladius)	4		
Parametriocnemus	1		
Paratanytarsus			1
Paratendipes	1	4	
Prosimulium	1		1
Rheotanytarsus			1
Simulium	2		1
Stempellinella	1	2	
Stictochironomus	2		
Sympotthastia	1		
Tanytarsus	2	6	
Tvetenia	1		1
Ameletus lineatus			3

Dardenne Creek Station 4, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Caenis latipennis	2	2	2
Centroptilum			1
Paraleptophlebia			2
Stenonema femoratum	1		Present, not counted
Caecidotea	1		
Lumbricidae		1	
Amphinemura	3		1
Clioperla clio			Present, not counted
Isoperla	9		Present, not counted
Perlesta	4		1
Perlinella drymo	Present, not counted		Present, not counted
Glossiphoniidae	2		
Rhyacophila			Present, not counted
Enchytraeidae	3	12	4
Limnodrilus cervix		1	
Limnodrilus hoffmeisteri		3	
Tubificidae		2	

Dardenne Creek Station 5, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina			1
Bactrurus		1	
Crangonyx		1	
Agabus			Present, not counted
Berosus		1	
Peltodytes		2	
Stenelmis			1
Ablabesmyia		3	
Ceratopogoninae	4	14	
Chaoborus		2	
Chironomus		5	
Cladotanytarsus	5	2	
Clinocera	3	1	
Corynoneura			7
Cricotopus trifascia	1		
Cricotopus/Orthocladius	170	6	67
Cryptochironomus	1		
Cryptotendipes		1	
Dicrotendipes	1	5	
Diplocladius			1
Diptera		2	
Eukiefferiella brevicalcar grp	3		1
Gonomyia	3		
Hexatoma	1	2	1
Hydrobaenus	318	88	176
Microtendipes		2	
Ormosia		3	
Orthocladius (Euorthocladius)	7		
Parachironomus		1	
Paratanytarsus			2
Paratendipes	3	45	2
Polypedilum convictum grp	2		
Polypedilum illinoense grp			2
Polypedilum scalaenum grp		1	
Prosimulium	4		
Rheocricotopus	2		6
Simulium	5		
Smittia	1		
Stempellinella	2	1	1
Stictochironomus		17	

Dardenne Creek Station 5, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Tanytarsus	2	9	1
Thienemannimyia grp.		1	
Tipula	1		Present, not counted
Tipulidae	1		
Tribelos		1	
Tvetenia bavarica grp	3		1
Zavrelimyia		1	
Caenis latipennis	7	8	7
Leptophlebia			Present, not counted
Paraleptophlebia			2
Stenonema femoratum	Present, not counted	1	
Caecidotea	Present, not counted	3	6
Physella			1
Lumbricidae		1	
Boyeria			Present, not counted
Calopteryx			1
Libellula		Present, not counted	
Amphinemura	7		2
Clioperla clio	Present, not counted		
Isoperla	34		3
Perlesta	12	1	1
Perlinella drymo		1	2
Ironoquia			1
Rhyacophila	1		
Triaenodes			1
Branchiura sowerbyi		1	
Enchytraeidae	1	7	2
Limnodrilus hoffmeisteri		6	
Tubificidae		10	

Dardenne Creek Station 5, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Hyalella azteca			13
Erpobdellidae	Present, not counted	Present, not counted	
Dubiraphia			1
Peltodytes		1	7
Scirtes			4
Stenelmis	4		
Tropisternus			Present, not counted
Orconectes virilis	Present, not counted	Present, not counted	
Ablabesmyia		1	
Ceratopogoninae	3	1	
Chaoborus	1		1
Chironomus		1	
Clinocera	22		
Constempellina		1	
Corynoneura		1	
Cricotopus trifascia	1		
Cricotopus/Orthocladius	209	18	37
Dicrotendipes	2		
Dixella			1
Dolichopodidae	1		
Eukiefferiella brevicalcar grp	1		1
Gonomyia	1		
Hexatoma	2	Present, not counted	
Hydrobaenus	373	315	294
Orthocladius (Euorthocladius)	15		
Paratanytarsus			4
Paratendipes	2	9	1
Polypedilum halterale grp		1	
Prosimulium	3		
Pseudochironomus		1	
Rheocricotopus	1		1
Simulium	5		
Stictochironomus	1		
Tabanus	1		
Tanytarsus	4	2	1
Thienemannimyia grp.	1		
Tipula	Present, not counted	Present, not counted	
Tvetenia	2		
Ameletus lineatus		Present, not counted	
Caenis latipennis	8		2

Dardenne Creek Station 5, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Centroptilum			6
Stenonema femoratum	9	Present, not counted	1
Ranatra fusca			Present, not counted
Caecidotea	1		1
Physella	Present, not counted	Present, not counted	1
Lumbricidae		Present, not counted	
Calopteryx	Present, not counted		
Enallagma			1
Nasiaeschna pentacantha			Present, not counted
Allocapnia			1
Amphinemura	3		
Chloroperlidae	9		
Clioperla clio	Present, not counted		
Isoperla	33		
Perlesta	23	Present, not counted	
Perlinella drymo		Present, not counted	
Cheumatopsyche	1		
Ironoquia			Present, not counted
Pycnopsyche	1		
Rhyacophila	3		
Triaenodes			1
Enchytraeidae	32		

North Fork Cuivre River Station 1a, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Crangonyx			1
Hyalella azteca			9
Berosus	1		
Dubiraphia	1	3	4
Oreodytes		6	
Peltodytes		2	1
Scirtes			1
Stenelmis	71	6	1
Orconectes virilis			Present, not counted
Ablabesmyia		5	4
Ceratopogoninae		1	
Chironomus		4	
Chrysops		1	
Cladotanytarsus		22	
Corynoneura	4	3	17
Cricotopus bicinctus	8		7
Cricotopus/Orthocladius	345	9	72
Cryptochironomus	1	2	
Demicryptochironomus	1		
Diamesa	1		
Dicrotendipes	1	8	7
Eukiefferiella brevicalcar grp	10		
Glyptotendipes			2
Gonomyia		1	
Hemerodromia	2		
Hydrobaenus	4	3	7
Lipiniella		4	
Microtendipes		1	1
Nanocladius			1
Ormosia		4	
Orthocladius (Euorthocladius)	18		
Parametriocnemus	2		
Paratanytarsus	4	2	105
Paratendipes	2	17	3
Phaenopsectra		3	2
Polypedilum convictum grp	3		
Polypedilum halterale grp		2	
Polypedilum illinoense grp	1	1	
Polypedilum scalaenum grp	6	7	
Procladius		1	
Rheotanytarsus	2		5
Simulium	3		

North Fork Cuivre River Station 1a, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Stempellinella	4		
Stictochironomus		59	6
Tabanus	Present, not counted		1
Tanytarsus	13	35	33
Thienemanniella	31		10
Thienemannimyia grp.	19	1	4
Tipula	Present, not counted		
Acerpenna	47		1
Caenis latipennis	25	55	103
Hexagenia limbata		1	
Stenacron	3	2	
Stenonema femoratum	23		5
Tricorythodes	1		
Belostoma			Present, not counted
Caecidotea			1
Physella			Present, not counted
Basiaeschna janata			Present, not counted
Enallagma			5
Gomphus		1	
Allocapnia	1		
Hydroperla crosbyi	Present, not counted		
Isoperla	7		
Perlesta	4		
Cheumatopsyche	5		
Pycnopsyche			1
Triaenodes			1
Planariidae			1
Branchiura sowerbyi		2	
Enchytraeidae	16	2	2
Limnodrilus hoffmeisteri	1	3	1
Tubificidae	14	14	1

North Fork Cuivre River Station 1b, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Branchiobdellida		1	
Hyalella azteca			8
Erpobdellidae	Present, not counted		
Berosus		3	1
Dubiraphia		5	1
Oreodytes		1	3
Peltodytes		2	1
Scirtes			2
Stenelmis	44	2	4
Orconectes luteus	Present, not counted		
Ablabesmyia		8	1
Ceratopogoninae		1	
Chironomus		8	
Cladotanytarsus	1	14	
Cnephia	1		
Corynoneura	13	3	9
Cricotopus bicinctus	2		7
Cricotopus/Orthocladius	282	13	61
Cryptochironomus	1	3	
Dicrotendipes		7	13
Eukiefferiella	1		
Eukiefferiella brevicalcar grp	2		
Glyptotendipes		1	1
Hydrobaenus	7	7	2
Larsia		1	
Microtendipes		1	1
Nanocladius	1		10
Ormosia	1	1	
Orthocladius (Euorthocladius)	17		
Parametriocnemus	3	1	
Paratanytarsus	1	4	64
Paratendipes	2	10	
Phaenopsectra		4	2
Polypedilum convictum grp	3		
Polypedilum halterale grp		11	
Polypedilum illinoense grp	1		4
Polypedilum scalaenum grp	4	5	
Pseudochironomus		2	
Rheotanytarsus	3		3
Stempellinella	1	4	1

North Fork Cuivre River Station 1b, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Stenochironomus			1
Stictochironomus		50	1
Tabanus	2		
Tanytarsus	13	32	14
Thienemanniella	39		7
Thienemannimyia grp.	21	1	20
Tipula	Present, not counted		
Acerpenna	48		
Caenis latipennis	39	63	91
Centroptilum			1
Stenacron	6		
Stenonema femoratum	22	3	2
Microvelia			1
Caecidotea	1		
Menetus			1
Physella			2
Argia			2
Enallagma			15
Progomphus obscurus		Present, not counted	
Allocapnia	5	1	
Amphinemura	2		
Hydroperla crosbyi	Present, not counted		
Isoperla	5		
Perlesta	1		
Perlinella drymo			Present, not counted
Cheumatopsyche	2		
Planariidae			1
Branchiura sowerbyi		2	
Enchytraeidae	11	2	
Limnodrilus hoffmeisteri	1	11	
Tubificidae	4	14	1
Sphaerium	1		

North Fork Cuivre River Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina		4	2
Crangonyx	3		8
Hyalella azteca			2
Erpobdellidae		1	
Berosus	1	4	
Dubiraphia		4	1
Gyrinus			1
Helichus lithophilus	1		
Hydroporus		2	2
Oreodytes		2	Present, not counted
Peltodytes		5	1
Stenelmis	36	1	2
Orconectes luteus	Present, not counted		Present, not counted
Orconectes virilis			Present, not counted
Ablabesmyia	1	2	
Ceratopogonidae		1	
Chironomus	6	4	
Chrysops	Present, not counted		
Cladotanytarsus		3	
Clinocera	1	1	
Corynoneura	3		18
Cricotopus bicinctus	4		6
Cricotopus trifascia	2		
Cricotopus/Orthocladius	280	13	100
Cryptochironomus	1	1	
Dicrotendipes	1	17	4
Eukiefferiella	1		1
Eukiefferiella brevicalcar grp	8		1
Glyptotendipes	1		
Hydrobaenus	57	4	1
Microtendipes	2	1	1
Nanocladius			1
Ormosia	1		
Orthocladius (Euorthocladius)	37		1
Parametriocnemus	9		
Paratanytarsus	1	1	18
Paratendipes	2	7	1
Phaenopsectra		1	8
Polypedilum convictum grp	6		
Polypedilum halterale grp			1

North Fork Cuivre River Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Polypedilum illinoense grp	1		10
Polypedilum scalaenum grp	19	2	
Procladius		1	
Pseudochironomus	3		
Rheotanytarsus	1		
Simulium			1
Stempellinella		5	1
Stictochironomus	7	3	
Tabanus	1		
Tanytarsus	2	28	12
Thienemanniella	17		24
Thienemannimyia grp.	11	4	5
Tipula	Present, not counted	Present, not counted	1
Tvetenia			2
Acerpenna	4		2
Caenis latipennis	10	127	61
Hexagenia limbata		4	
Stenonema femoratum	14	12	11
Microvelia		1	
Trichocorixa		1	
Ferrissia	3	1	1
Fossaria			Present, not counted
Physella	1	1	8
Lumbricidae	1	1	
Sialis		Present, not counted	
Basiaeschna janata			Present, not counted
Calopteryx			Present, not counted
Enallagma			7
Gomphus		Present, not counted	
Libellula		Present, not counted	
Allocapnia	1		
Amphinemura	1		
Isoperla	Present, not counted		
Perlesta	1		
Glossiphoniidae			1
Cheumatopsyche	6		
Chimarra	2		
Ironoquia			Present, not counted
Oecetis	1		
Enchytraeidae	3	1	1

North Fork Cuivre River Station 2, Spring 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Limnodrilus cervix		5	
Limnodrilus hoffmeisteri		18	
Tubificidae	1	99	2
Sphaerium		1	1

Dardenne Creek Station 1, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina	12	19	5
Hyalella azteca	1	6	31
Erpobdellidae	Present, not counted		
Berosus	1	1	
Dubiraphia			18
Helichus lithophilus	2		
Macronychus glabratus			2
Scirtes	1		8
Stenelmis	22	1	
Procambarus acutus			Present, not counted
Ablabesmyia	1	2	10
Axarus		1	
Ceratopogoninae	2	34	11
Chaoborus		3	
Chironomus		14	
Cladopelma		40	3
Corynoneura	1		1
Cricotopus/Orthocladius		2	10
Cryptochironomus	3	2	
Cryptotendipes		3	
Culex			5
Dasyheleinae			1
Demicryptochironomus	1		
Dicrotendipes		11	11
Dixella		1	3
Endochironomus			63
Glyptotendipes			12
Hemerodromia	5		
Hexatoma	Present, not counted		
Labrundinia	1	1	12
Microtendipes	2		
Nanocladius		3	1
Natarsia			1
Nilotanypus	2		
Nilothauma	1		
Ormosia		1	
Parakiefferiella		1	2
Paralauterborniella	1		
Paratanytarsus	1	1	54
Phaenopsectra			4

Dardenne Creek Station 1, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Polypedilum	1		
Polypedilum convictum grp	108		6
Polypedilum illinoense grp	8	6	14
Polypedilum scalaenum grp	4	1	
Procladius		1	1
Pseudochironomus		1	3
Pseudosmittia			1
Rheotanytarsus	126		1
Stempellinella	1	1	1
Stenochironomus		1	
Tabanus	1		Present, not counted
Tanypus		7	
Tanytarsus	72	7	28
Thienemannimyia grp.	26		2
Tribelos		1	1
Xenochironomus			1
Zavreliella		1	
Acerpenna	53		
Apobaetis		1	
Baetidae		1	1
Caenis latipennis	12	32	15
Callibaetis			3
Hexagenia limbata		6	
Procloeon		1	
Stenacron	6		11
Stenonema femoratum		1	
Tricorythodes	3		
Belostoma			Present, not counted
Corixidae		2	
Ranatra kirkaldyi			Present, not counted
Rhagovelia	2		
Ancylidae	1		
Menetus		1	8
Physella	3		4
Lumbricidae	Present, not counted	1	
Corydalus	Present, not counted		
Sialis			Present, not counted
Argia	1	1	2
Basiaeschna janata			Present, not counted
Boyeria			Present, not counted

Dardenne Creek Station 1, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Calopteryx	3		
Enallagma			13
Gomphidae		1	
Macromia		1	
Progomphus obscurus	Present, not counted		
Cheumatopsyche	238	1	
Chimarra	29		
Hydroptila	13	1	1
Oecetis	1	3	9
Orthotrichia			8
Oxyethira		6	
Planariidae	2		1
Aulodrilus		3	
Branchiura sowerbyi	1		1
Tubificidae	4	14	1
Sphaerium	3		2

Dardenne Creek Station 2, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina	3	36	10
Hyalella azteca		9	92
Berosus	8	2	4
Dubiraphia		9	9
Helichus lithophilus	5		
Scirtes			2
Stenelmis	15		
Ablabesmyia	5	10	3
Ceratopogoninae	16	23	7
Chironomus		11	1
Chrysops		Present, not counted	
Cladopelma		3	
Cladotanytarsus	2	3	
Corynoneura	6		
Cricotopus bicinctus	1		
Cricotopus/Orthocladius	1		23
Cryptotendipes		2	
Dicrotendipes	2	8	5
Dixella			3
Hemerodromia	1		
Hexatoma	3		
Labrundinia	1	2	3
Larsia			1
Nanocladius		2	
Nilotanypus	8		
Paratanytarsus		4	10
Paratendipes	3		
Polypedilum convictum grp	10		
Polypedilum halterale grp		3	
Polypedilum illinoense grp	6	1	
Polypedilum scalaenum grp	14	1	
Procladius		2	1
Pseudochironomus		3	7
Rheotanytarsus	7		
Stempellinella	22	4	7
Stictochironomus		1	
Tabanus	7		
Tanypus		1	
Tanytarsus	45	18	9
Thienemannimyia grp.	14		

Dardenne Creek Station 2, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
undescribed Empididae	2		
Zavreliella		1	
Zavrelimyia	2		
Acentrella	1		
Acerpenna	13		
Apobaetis		1	
Caenis latipennis	170	77	1
Hexagenia		2	
Leptophlebiidae			1
Procloeon		2	
Stenacron	9		
Stenonema femoratum	8	5	
Tricorythodes	8	1	
Mesovelia	1		
Rhagovelia	1		
Rheumatobates		1	
Ancylidae	3	1	
Menetus	1	3	
Physella	33	4	
Sialis		Present, not counted	
Argia	19	1	21
Boyeria			1
Calopterygidae	1		
Enallagma			22
Gomphus	2		
Hagenius brevistylus	7		
Libellula		2	
Macromia		1	Present, not counted
Progomphus obscurus	2		
Cheumatopsyche	75		
Chimarra	32		
Hydroptila	5	3	1
Leptoceridae		2	
Oecetis	1	3	
Oxyethira		1	
Polycentropus			1
Triaenodes			2
Planariidae	1		
Aulodrilus		1	
Branchiura sowerbyi		1	1

Dardenne Creek Station 2, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Limnodrilus cervix		1	
Tubificidae	3	9	1

Dardenne Creek Station 3, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina		7	5
Crangonyx	1		
Hyalella azteca	2	1	48
Berosus	35		4
Dubiraphia		3	13
Helichus lithophilus	5		
Lutrochus	1		
Scirtes			5
Stenelmis	8		
Tropisternus	3		
Orconectes virilis			1
Ablabesmyia	5	8	2
Ceratopogoninae	5	106	31
Chaoborus		1	
Chironomus	53	2	1
Cladopelma		9	
Cladotanytarsus	6	2	
Corynoneura	2		
Cricotopus/Orthocladius			2
Cryptotendipes		2	
Culex			4
Dasyheleinae	3	9	4
Dicrotendipes	15	3	5
Diptera	2		
Djalmabatista	1		
Einfeldia		27	1
Endochironomus			1
Forcipomyiinae	4	1	1
Glyptotendipes			3
Hemerodromia	3		
Hexatoma	2		
Labrundinia		3	6
Larsia			1
Microtendipes	4		
Nanocladius			2
Paratanytarsus	1	1	19
Paratendipes	3		
Pentaneura	3		
Polypedilum convictum grp	10		1
Polypedilum halterale grp		3	

Dardenne Creek Station 3, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Polypedilum illinoense grp	15	8	28
Polypedilum scalaenum grp	13		
Procladius	2	6	
Pseudochironomus	5	2	1
Psychoda	1		
Rheotanytarsus	1		
Stempellinella	1		
Stenochironomus	1		1
Tabanus	1	Present, not counted	
Tanypus	1	13	
Tanytarsus	142	35	27
Thienemanniella	1		1
Thienemannimyia grp.	6		1
Tipula	Present, not counted		
Tribelos			1
undescribed Empididae	1		
Zavreliella		1	
Zavrelimyia	1	2	3
Acerpenna	2		
Baetidae			1
Caenis latipennis	119	53	27
Callibaetis			3
Hexagenia limbata	2		
Leptophlebiidae			2
Procloeon		3	
Stenonema femoratum	4		
Tricorythodes	7		
Gerridae	1		1
Ancylidae	4		8
Menetus	3		8
Physella	5	4	24
Argia	8		
Basiaeschna janata	Present, not counted		
Enallagma		1	15
Epitheca (Tetragoneuria)			Present, not counted
Erythemis	Present, not counted	3	2
Gomphidae	1		
Libellula		Present, not counted	
Libellulidae			4
Macromia	Present, not counted	Present, not counted	

Dardenne Creek Station 3, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Progomphus obscurus	2		
Cheumatopsyche	4		
Chimarra	9		
Hydroptila	14		1
Oecetis	2	3	5
Triaenodes			2
Planariidae	8		1
Aulodrilus		6	
Limnodrilus hoffmeisteri		3	
Tubificidae		4	

Dardenne Creek Station 4a, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Gordiidae		1
Acarina	1	3
Hyalella azteca	3	86
Dubiraphia		15
Hydrochus		2
Scirtes	2	27
Orconectes virilis		Present, not counted
Palaemonetes kadiakensis		Present, not counted
Ablabesmyia		1
Ceratopogoninae	15	4
Chaoborus	5	
Chironomus	88	9
Cladotanytarsus	23	
Culex		3
Dicrotendipes	13	19
Forcipomyiinae		1
Glyptotendipes	1	40
Labrundinia		2
Microtendipes		1
Parachironomus	1	5
Paratanytarsus		8
Polypedilum halterale grp	14	
Procladius	13	
Stictochironomus	1	
Tanypus	6	
Tanytarsus	71	1
Thienemannimyia grp.		1
Tribelos		5
Caenis latipennis	1	2
Callibaetis		1
Leptophlebiidae		8
Mesovelia		1
Ferrissia		1
Menetus		17
Physella	1	1
Chauliodes rastricornis		Present, not counted
Argia		5
Boyeria		Present, not counted
Didymops		Present, not counted
Enallagma		25

Dardenne Creek Station 4a, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Gomphus		Present, not counted
Libellula		1
Nasiaeschna pentacantha		1
Polycentropus		3
Triaenodes		11
Planariidae		3
Branchiura sowerbyi	10	
Limnodrilus hoffmeisteri	3	
Tubificidae	52	

Dardenne Creek Station 4b, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Acarina	4	11
Hyalella azteca		66
Dubiraphia	1	21
Enochrus		1
Gyrinus		1
Scirtes		29
Orconectes virilis		Present, not counted
Aedes		1
Ceratopogoninae	20	8
Chaoborus	2	
Chironomus	74	11
Cladotanytarsus	13	
Cryptochironomus	1	
Culex		4
Dicrotendipes	16	15
Dixella		1
Forcipomyiinae		1
Glyptotendipes	3	13
Kiefferulus		4
Paratanytarsus	1	6
Paratendipes	3	
Phaenopsectra		2
Polypedilum halterale grp	12	
Procladius	15	1
Stempellinella		1
Stictochironomus	1	
Tanypus	4	
Tanytarsus	51	6
Thienemannimyia grp.		1
Caenis latipennis	15	2
Centroptilum	1	
Leptophlebiidae		7
Ranatra kirkaldyi		Present, not counted
Ancylidae	1	14
Menetus		27
Physella	1	1
Chauliodes		1
Sialis		Present, not counted
Argia		5
Boyeria		1

Dardenne Creek Station 4b, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Enallagma		12
Epitheca (Tetragoneuria)		Present, not counted
Nasiaeschna pentacantha		Present, not counted
Pachydiplax longipennis	Present, not counted	
Progomphus obscurus	Present, not counted	
Oecetis		1
Polycentropus		1
Triaenodes		12
Planariidae		4
Aulodrilus	4	
Branchiura sowerbyi	4	
Limnodrilus hoffmeisteri	4	
Tubificidae	6	

Dardenne Creek Station 5, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Acarina		1
Hyalella azteca	3	209
Dubiraphia	9	4
Macronychus glabratus		2
Scirtes		10
Stenelmis	1	
Orconectes virilis		Present, not counted
Ablabesmyia	7	3
Ceratopogoninae	4	
Chaoborus	2	
Chironomus	26	
Cladopelma	1	
Cladotanytarsus	9	
Cryptochironomus	2	
Culex		1
Dicrotendipes	6	3
Dixella		1
Forcipomyiinae		2
Glyptotendipes	4	1
Hexatoma	1	
Labrundinia		2
Larsia	1	
Microtendipes	1	
Parachironomus	1	5
Paratanytarsus	3	6
Paratendipes	2	
Polypedilum halterale grp	2	
Polypedilum illinoense grp		1
Polypedilum scalaenum grp	2	
Pseudochironomus	1	
Stempellinella	11	
Stenochironomus		1
Stictochironomus	2	
Tanypus	3	
Tanytarsus	26	1
Thienemannimyia grp.		1
Tribelos	8	1
Caenis latipennis	76	3
Callibaetis		1
Hexagenia	20	

Dardenne Creek Station 5, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Leptophlebiidae		1
Procloeon	1	
Stenacron	1	1
Stenonema femoratum	13	1
Ancylidae	3	1
Menetus	3	6
Physella	3	1
Climacia		1
Argia	2	3
Boyeria		Present, not counted
Enallagma		2
Erythemis		2
Tramea		Present, not counted
Cernotina		1
Hydroptila		2
Nectopsyche		1
Oecetis		2
Triaenodes		21
Planariidae		10
Branchiura sowerbyi	2	
Limnodrilus hoffmeisteri	1	
Tubificidae	17	

Dardenne Creek Station 6, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Acarina	11	2
Hyalella azteca	4	76
Berosus	1	4
Dubiraphia	9	1
Helichus lithophilus		2
Scirtes	1	
Stenelmis		2
Orconectes virilis	Present, not counted	Present, not counted
Ablabesmyia	8	
Ceratopogoninae	18	6
Chaoborus	3	
Cladopelma	2	
Cladotanytarsus	2	
Clinotanypus	1	
Cricotopus/Orthocladius		1
Cryptochironomus	2	
Cryptotendipes	2	
Dicrotendipes	1	
Glyptotendipes	3	2
Labrundinia	2	11
Larsia	1	7
Parachironomus	1	2
Paratanytarsus		4
Polypedilum halterale grp	2	
Polypedilum illinoense grp	6	30
Procladius	5	1
Pseudochironomus	3	3
Stempellinella	1	
Stictochironomus	4	
Tabanus		1
Tanypus	4	
Tanytarsus	4	8
Thienemannimyia grp.	1	
Zavreliella	2	1
Zavrelimyia	1	2
Caenis latipennis	146	41
Callibaetis	1	
Heptageniidae	3	
Hexagenia	5	
Hexagenia limbata	Present, not counted	

Dardenne Creek Station 6, Fall 2002

Taxa	Non-Flow Habitat	Root Mat Habitat
Stenacron	1	
Stenonema femoratum	9	
Gerridae		4
Mesovelia		1
Neoplea		2
Fossaria		4
Menetus	3	14
Physella	7	34
Lumbricidae	2	
Argia		20
Enallagma	2	60
Erythemis	1	13
Gomphus	Present, not counted	
Libellulidae	2	5
Oecetis	3	4
Triaenodes		9
Branchiura sowerbyi	5	
Tubificidae	8	4

North Fork Cuivre River Station 1a, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina		6	7
Erpobdellidae	Present, not counted	Present, not counted	
Berosus	9	2	30
Dubiraphia		8	11
Enochrus	5		
Helichus lithophilus			3
Scirtes	1		12
Stenelmis	206	2	7
Ablabesmyia	15	1	
Anopheles			1
Ceratopogoninae	4	16	
Chironomus		13	
Chlorotabanus			Present, not counted
Cladopelma		1	
Cladotanytarsus	1	5	
Cricotopus bicinctus	2		
Cricotopus/Orthocladius	3		
Cryptochironomus	1		
Culex			1
Dasyheleinae	1	1	
Demicryptochironomus	2		
Dicrotendipes	1	1	4
Diptera			1
Dolichopodidae	1		
Ephydridae	1		
Forcipomyiinae	2		
Glyptotendipes	2		9
Hemerodromia	2		
Labrundinia	1		5
Nilotanypus	2		
Parachironomus			2
Paratanytarsus			5
Paratendipes	1		
Pentaneura	2		
Polypedilum	1		1
Polypedilum convictum grp	16		
Polypedilum halterale grp	1	9	
Polypedilum illinoense grp	18	1	1
Polypedilum scalaenum grp	15	2	
Procladius		7	1

North Fork Cuivre River Station 1a, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Rheotanytarsus	13		
Stempellinella	1	1	
Stictochironomus	1	1	
Tabanus	2		
Tanytarsus	46	11	4
Thienemanniella	1		
Thienemannimyia grp.	16		2
Caenis latipennis	97	18	4
Callibaetis			1
Choroterpes	1		
Hexagenia		1	
Procloeon		4	
Stenonema femoratum	3		
Tricorythodes	65	1	
Microvelia			1
Caecidotea (Blind & Unpigmented)	1		
Ancylidae	9	1	4
Menetus			72
Physella	76	2	21
Argia	1		14
Enallagma		1	9
Erythemis			Present, not counted
Gomphidae		1	
Gomphus			1
Macromia			Present, not counted
Nasiaeschna pentacantha			Present, not counted
Glossiphoniidae		1	
Ceratopsyche	1		
Cheumatopsyche	28	1	
Nectopsyche			1
Oecetis	1		
Pycnopsyche			Present, not counted
Planariidae			26
Aulodrilus		12	1
Branchiura sowerbyi	2	41	1
Limnodrilus cervix		2	
Limnodrilus hoffmeisteri		22	
Tubificidae	6	134	4
Sphaerium	3	3	7

North Fork Cuivre River Station 1b, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Chordodidae	Present, not counted		
Acarina	1	10	5
Hyalella azteca			1
Berosus	9	3	28
Dubiraphia		3	16
Enochrus	2		
Helichus lithophilus	9		
Macronychus glabratus			5
Paracymus	1		
Scirtes			6
Stenelmis	183	3	9
Ablabesmyia	5	1	1
Anopheles			1
Axarus	1		
Ceratopogoninae	8	9	
Chaoborus		2	
Chironomus		15	
Cladotanytarsus	3	16	
Cricotopus/Orthocladius	2		
Cryptochironomus	14	3	
Dasyheleinae		1	
Demicryptochironomus	3		
Dicrotendipes	2	1	6
Diptera	2	1	
Forcipomyiinae	2	1	
Glyptotendipes			15
Hemerodromia	1		
Labrundinia			9
Nanocladius		1	1
Nilotanypus	1		
Parachironomus			5
Paratanytarsus		2	19
Paratendipes	5	1	
Phaenopsectra			2
Polypedilum convictum grp	40		
Polypedilum halterale grp	1	10	
Polypedilum illinoense grp	27		1
Polypedilum scalaenum grp	24	2	
Procladius		4	
Pseudochironomus		1	

North Fork Cuivre River Station 1b, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Rheotanytarsus	6		
Stempellinella	3	5	
Stictochironomus		1	
Tabanus	4		
Tanypus		1	
Tanytarsus	73	36	18
Thienemanniella	1		1
Thienemannimyia grp.	10		1
Caenis latipennis	131	39	15
Choroterpes	1		
Procloeon		2	
Stenacron	2		1
Stenonema femoratum	19	3	
Tricorythodes	32		
Ancylidae	6		14
Menetus		1	102
Physella	44	6	29
Argia	4		14
Enallagma	1		41
Gomphus		3	
Libellulidae		1	
Progomphus obscurus		Present, not counted	
Cheumatopsyche	17		
Chimarra	1		
Hydroptila			1
Nectopsyche		1	1
Nyctiophylax			1
Oecetis	1		2
Pycnopsyche			1
Triaenodes			1
Planariidae			55
Branchiura sowerbyi	2	13	
Enchytraeidae	1		
Limnodrilus cervix		5	
Limnodrilus hoffmeisteri		12	
Tubificidae	4	101	

North Fork Cuivre River Station 2, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina	18	21	6
Berosus	20	1	16
Dubiraphia		1	11
Enochrus	6		1
Helichus lithophilus			3
Macronychus glabratus			1
Scirtes			11
Stenelmis sexlineata	36	1	2
Ablabesmyia	5	5	1
Anopheles			1
Ceratopogoninae	10	6	
Chironomus	2	35	
Cladotanytarsus	11	11	1
Corynoneura			1
Cryptochironomus		2	
Dicrotendipes	2	6	
Labrundinia		1	6
Microtendipes	1		
Nilotanypus	5		
Paracladopelma		1	
Paratanytarsus			15
Paratendipes	4	1	
Pentaneura	1		
Phaenopsectra			1
Polypedilum convictum grp	16		1
Polypedilum halterale grp		2	
Polypedilum illinoense grp	15	1	3
Polypedilum scalaenum grp	58	2	
Procladius	1	5	
Pseudochironomus	2		
Rheotanytarsus	6	1	
Stempellinella	10	1	
Stenochironomus			1
Tabanus	1		
Tanytarsus	68	6	1
Thienemannimyia grp.	12		7
undescribed Empididae	13		
Baetidae	1		
Caenis latipennis	99	101	34
Procloeon		2	

North Fork Cuivre River Station 2, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Stenacron	3		1
Stenonema femoratum	9	1	8
Tricorythodes	13		
Microvelia			2
Rhagovelia	1		
Trepobates		1	
Ancylidae	17	38	155
Fossaria	5		2
Menetus	5	9	4
Physella	50	1	24
Lumbricidae	1		
Argia	Present, not counted	1	6
Basiaeschna janata			Present, not counted
Calopteryx	Present, not counted		1
Enallagma			28
Erythemis			1
Gomphus		Present, not counted	
Ischnura			1
Macromia			Present, not counted
Somatochlora		Present, not counted	
Cheumatopsyche	7		
Chimarra	8		
Helicopsyche	1		
Hydroptila			1
Nectopsyche			2
Oecetis		1	
Triaenodes			2
Aulodrilus		13	
Enchytraeidae	1		
Limnodrilus hoffmeisteri		2	
Tubificidae	5	22	
Sphaerium		1	1

South River Station 1, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Acarina			14
Berosus	7	4	15
Dubiraphia		19	57
Helichus lithophilus			1
Scirtes	1		3
Stenelmis	11		
Orconectes luteus	Present, not counted		
Ablabesmyia			2
Ceratopogoninae	1	12	13
Chironomus		3	3
Cladopelma		1	
Cladotanytarsus		29	
Cricotopus/Orthocladius			1
Cryptochironomus	2	5	
Dicrotendipes	1		4
Hexatoma	1		
Labrundinia	1		7
Microtendipes			2
Nanocladius			14
Nilotanypus	4		
Paratanytarsus			13
Phaenopsectra			2
Polypedilum convictum grp	11	1	2
Polypedilum scalaenum grp	1		
Procladius		1	1
Rheocricotopus	1		
Rheotanytarsus	2		
Stempellinella	5		9
Tabanus	Present, not counted		
Tanytarsus	9	1	23
Thienemanniella	3		5
Thienemannimyia grp.	12		19
Acerpenna	1		
Baetis	6		
Caenis latipennis	9	27	1
Heptageniidae	3		
Hexagenia limbata		Present, not counted	
Procloeon			1
Stenacron			1
Stenonema femoratum	2		

South River Station 1, Fall 2002

Taxa	Coarse Substrate Habitat	Non-Flow Habitat	Root Mat Habitat
Tricorythodes	563		1
Trichocorixa		39	
Ancylidae	14	2	
Lymnaeidae	2	1	
Menetus	4		39
Physella	14		5
Lumbricidae	1		
Sialis		Present, not counted	
Argia			4
Dromogomphus		Present, not counted	
Enallagma			27
Epitheca (Epicordulia)			Present, not counted
Hetaerina	1		
Plathemis		Present, not counted	
Cheumatopsyche	21		
Chimarra	159		1
Helicopsyche	46	2	
Oecetis	17		1
Triaenodes			20
Planariidae	8		20
Aulodrilus			2
Branchiura sowerbyi		14	
Limnodrilus hoffmeisteri		6	
Tubificidae		79	1
Pisidium		2	
Sphaerium	1	2	

Appendix D

Analysis of Variance Results of
Benthic Fine Sediment Estimates

One Way Analysis of Variance

Data source: Dardenne ANOVA on Ranks and Dunns

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: Dardenne Creek Benthic Sediment Data

Group	Station	N	Missing	Median	25%	75%
1.000	Dardenne Ck 1	6	0	100.000	100.000	100.000
2.000	Dardenne Ck 2	18	0	92.500	35.000	100.000
3.000	Dardenne Ck 3	18	0	92.500	35.000	100.000
4.000	Dardenne Ck 4	18	0	95.000	40.000	100.000
5.000	Dardenne Ck 5	12	0	15.000	5.000	20.000
11.000	N Fk Cuivre R 1	18	0	5.000	5.000	15.000
21.000	N Fk Cuivre R 2	12	0	90.000	17.500	100.000

H = 41.467 with 6 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
1 vs 11	62.806	4.503	Yes
1 vs 5	55.458	3.749	Yes
1 vs 21	27.708	1.873	No
1 vs 3	25.306	1.814	Do Not Test
1 vs 2	21.972	1.575	Do Not Test
1 vs 4	21.472	1.539	Do Not Test
4 vs 11	41.333	4.191	Yes
4 vs 5	33.986	3.082	Yes
4 vs 21	6.236	0.566	Do Not Test
4 vs 3	3.833	0.389	Do Not Test
4 vs 2	0.500	0.0507	Do Not Test
2 vs 11	40.833	4.140	Yes
2 vs 5	33.486	3.037	No
2 vs 21	5.736	0.520	Do Not Test
2 vs 3	3.333	0.338	Do Not Test

3 vs 11	37.500	3.802	Yes
3 vs 5	30.153	2.734	Do Not Test
3 vs 21	2.403	0.218	Do Not Test
21 vs 11	35.097	3.183	Yes
21 vs 5	27.750	2.297	Do Not Test
5 vs 11	7.347	0.666	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.